A21 DIKE:

TECHNICAL SPECIFICATIONS

Prepared for:

Diavik Diamond Mines Inc.
Yellowknife, Northwest Territories

Prepared by:

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August 2007

DIAVIK DIAMOND MINES
A21 WATER RETENTION DIKE

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1.0 LOCATION

1. The A21 Dike Project is located at approximately latitude 64°31´ North and longitude 1 10°20´ West. The project site is situated on South Island, on the eastern side of Lac de Gras, and is about 300 km northeast of Yellowknife in the Northwest Territories, Canada.

2.0 SURFACE CONDITIONS

1. The mine site is located north of the tree line, in the continuous permafrost zone.

2. The topography on and in the vicinity of the site is gently rolling, with low to moderate relief. The average elevation of the site is 430 meters above mean sea level. The ground surface is rolling, with hills rising to about 40 meters above lake level.

3. The island is underlain by predominantly granite bedrock of the Canadian Shield. Bedrock is exposed over about 40 percent of the surface area of the island. The balance of the island is covered by ice rich glacial till deposits, with occasional organic deposits and peat in poorly drained depressions.

3.0 AIR TEMPERATURES

1. The mean annual air temperature at the site is approximately - 10°C. The mean monthly air temperature varies from about - 32°C in January to +10°C in July and exceeds the freezing point only during the period from late May to early September.

2. The mean annual freezing index is about 5000 Celsius degree-days while the mean annual thawing index is about 1100 Celsius degree-days.

4.0 PRECIPITATION

1. The average annual precipitation is about 373 mm. Of this approximately 40% occurs as rainfall (144 mm) and 60% occurs as snowfall (229 mm, converted to water). Precipitation may occur as rainfall for the six months from May to October. The 24 hour extreme rainfall with a 10 year return period is 48 mm.

5.0 LIGHTNING

1. Lightning is common in the Lac de Gras area during the thaw season.

6.0 WIND

1. The direction of origin of the wind and its mean speed and frequency of occurrence are as follows:

Wind Direction (origin)	Mean Wind Speed (km/hr)	Frequency of Occurrence (%)
North	20.2	12
Northeast	15.5	9
East	16.6	15
Southeast	16.5	11
South	17.9	10
Southwest	17.2	12
West	19.2	18
Northwest	23.9	13

2. The 10 year and 100 year hourly wind speeds are estimated to be about 100 and 128 km/hr from the northwest. Other directions correspond with lower wind speeds.

7.0 LAKE ICE

1. The mean date of the first occurrence of permanent ice on Lac de Gras is October 9. The earliest and latest recorded occurrences are September 28 and October 27 respectively. The mean date for the lake to be clear of ice is June 26. The earliest and latest recorded occurrences are June 9 and July 14 respectively.

2. The mean maximum ice thickness is 1.7 meters. The thickness of the ice can vary significantly over the lake due to currents and other factors.

8.0 SEISMICITY

1. The project area is situated in the Canadian Shield which is considered to be a seismically inactive part of Canada without identifiable active faults and is located at significant distances from other active seismic zones. These may impart a peak ground acceleration at site in the order of 0.023 g for a probability of exceedance of 1 % in 100 years (equivalent return period of 10000 years) according to the current seismic zonation. Note that the values proposed for the 2005 National Building Code for an exceedance of 2 % in 50 years (2500 yr return period) are 0,059 for Yellowknife and Fort Resolution.

-END OF SPECIFICATION

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1.0 GENERAL

1.1 Scope of Specification

1. The Work refers to the construction site work at South Island and East Island. This specification relates to environmental protection measures associated with the Work. It includes, but is not limited to:

    - Protection of surface features (i.e. soils, vegetation, and permafrost);
    - Protection of aquatic resources (i.e. lakes, streams, and other water courses/water bodies);
    - Protection of air quality (i.e. with respect to noise, dust, and pollution);
    - Protection of wildlife and wildlife habitat; and
    - Protection of heritage/archaeological resources.

2. The environmental protection measures include provision of suitable waste disposal means, including, but not limited to disposal of :

    - Construction wastes;
    - Sanitary wastes;
    - Process wastes; and
    - Any other waste materials generated during the conduct of the Work.

3. Environmental protection, as it relates to the Work, requires adherence to all applicable Municipal, Territorial, and Federal Legislation, including Regulations, Orders, Standards, and Guidelines. It requires adherence to all conditions provided in the Diavik Diamonds documents referred to in Section 1.2 below. Environmental protection also includes obtaining and complying with provisions of all Permits, Permissions, Allowances and Licenses required by governing bodies for the conduct of the Work.

1.2 Reference Standards

1. The following publications shall be referred to for additional information with respect to legislation and regulations applicable to this Work:

    - Diavik Diamonds Construction Hazardous Substances Management Plan
    - Diavik Diamonds Construction Waste Management Plan
    - Diavik Diamonds Construction Emergency Response Plan

- Diavik Diamonds Construction Health/Safety Plan
- Diavik Diamonds Construction Area and Activity Environmental Management Plan
- Canadian Environmental Protection Act
- NWT Environmental Protection Act
- Fisheries Act
- NWT Waters Act
- CCME Environmental Code of Good Practice for Aboveground Storage Tank Systems
- Containing Petroleum Products
- NWT Mine, Health and Safety Act and Regulations
- Fire Prevention Act of the NWT
- National Fire Code of Canada (NFCC)

2. The first five documents are available for review in DDMI's office in Yellowknife.

1.3 Submittals

1.3.1 Initial Submissions

1. The Contractor shall submit the following to the Manager for review and acceptance prior to starting the Work or engaging in new aspects of the Work:

   - **Design**

     Design of all environmental protection measures which are included in the Work or incidental thereto.

   - **Methodology**

     Methodology for all environmental protection measures which are included in the Work or incidental thereto.

   - **Emergency Response Plan**

     Emergency Response Plan for protection of the environment.

- **Responsible Parties**

  The names of all responsible parties to the Work and how these persons may be contacted at any time.

1.3.2 Intermittent Submissions:

1. The Contractor shall submit evidence of valid Licenses, Permits, Permissions, and Approvals if requested by the Manager, and/or any governing body.

1.4 Definitions

1. **ENVIRONMENT** means all natural physical, chemical and biological components as well as all social, cultural and historic components of East Island and any other geographic areas directly associated with the Work.

2. **WATER BODY** shall mean any body of water, whether moving or still, including, but not limited to, rivers, streams, creeks, lakes, ponds, marshes, sloughs, swamps, bogs, ditches with water in them, and shall include the area bounded by these bodies up to and including the high water mark.

2.0 PRODUCTS

NOT APPLICABLE

3.0 EXECUTION

3.1 General

1. The Contractor shall protect the environment to the satisfaction of the Manager, and all agencies having jurisdiction, and assure the lowest degree of environmental degradation at the Site during and as a result of the Work.

2. Special care shall be taken to prevent any harmful chemicals such as diesel fuel, gasoline, or other products from entering the soil or adjacent water systems, particularly when refueling equipment.

3.2 Surface Features

3.2.1 Erosion Control:

1. Exposed, erosion prone soils shall be protected from erosion by one or more of the following methods:

    - Covering with a suitable material such as plastic, geotextile or gravel;
    - Installation of erosion bars, stone check dams, and water diversion structures;
    - Application of a soil binding spray.

2. Ditches and waterways shall be protected from erosion by one or more of the following methods:

    - Lining with an erosion resistant material;
    - Construction of silt fences using suitable geotextile, or utilizing prefabricated silt fencing;
    - Diversion of water around the erosive area using flexible pipe, corrugated steel pipe, or other suitable conduit;

      Installation of hoarding or other rigid fencing where there is potential for large debris to enter the watercourse.

3. Ditches and culverts shall be properly sized to accommodate anticipated flows.

4. Erosion protection measures shall be undertaken under the direction of the Manager.

5. Re-vegetation, if required, shall be by others.

6. Further information regarding policy on silt fences and erosion control can be found in the Diavik Diamonds Construction Area and Activity Environmental Management Plan.

3.2.2 Vegetation and Permafrost Protection:

1. The Contractor shall avoid unnecessary damage to vegetation, and the ground surface in the areas adjacent to the Work.

Removal or disturbance of the surface vegetation in permafrost areas has the potential to cause significant permafrost degradation. The Contractor shall not remove the surface vegetation or organic soils unless prior written approval has been obtained from the Manager.

3.3 Aquatic Resources

3.3.1 Watercourse Environmental Protection:

1. .1 A Watercourse Environmental Protection Zone shall exist within 75 metres of the high water mark of all water bodies, with the exception of onshore and offshore construction related activities, as approved by the Manager.

2. .2 If any of the Work is undertaken within a Watercourse Environmental Protection Zone, the Contractor is advised that conduct of the Work will require particular care to protect the environment.

3. .3 Activities undertaken within a Watercourse Environmental Protection Zone shall be limited to that absolutely necessary for the performance of the Work. The following activities shall be undertaken only with the specific approval of the Manager:

    - Fueling or servicing equipment;
    - Washing of equipment;
    - Disposal of waste materials, including, but not limited to, waste rock and soils, construction wastes, garbage, or any other materials;
    - Blasting resulting in deposition of rock or other materials within the wet perimeter of a water body.

4. Work undertaken within a Watercourse Environmental Protection Zone shall be conducted as expeditiously as possible.

5. No fuels, oils, grease, or any other substance, including, but not limited to, paints, solvents, chemicals, cement, grout, or building materials may be stored within a Watercourse Environmental Protection Zone without the specific approval of the Manager.

6. Work within the wet perimeter of a water body shall be conducted under the inspection and with the approval of the Manager and the regulatory authority when required. Plans and methods for such Work shall be submitted to the Manager for approval prior to undertaking such Work.

7. Suitable diversions, coffer dams, and other structures shall be established prior to any Work within the wet perimeter of a water body where feasible.

8. The Contractor shall ensure that no substances deleterious to fish or fish habitat enter a water body or are placed in such a location that they could enter a water body.

9. Work in and about watercourses shall be avoided during times of fish spawning, aggregation, migrations, and other sensitive periods.

3.3.2 Water Quality Protection:

1. The Contractor shall detain, or otherwise manage all waters exiting the Site of the Work to ensure that suspended solids, sediments, concrete and/or grout wash water, oil and grease, or any other material is removed, to a level which meets the requirements of the DDMI environmental and waste management plans.

2. A sump shall be excavated to contain all excess concrete, laitance, and concrete washwater. The sump shall be located a sufficient distance from watercourses to prevent accidental contamination of the water body. Materials collected in the sump shall be disposed of in a manner consistent with Territorial and local regulations. Further information on disposal of wastes may be found in the Diavik Diamonds Construction Waste Management Plan.

3. All concrete forms used in and around watercourses shall be tight fitting to prevent concrete and laitance from contaminating the watercourse or soils. All water displaced from concrete forms during pouring of the concrete shall be directed into the above mentioned sump.

4. All cast in place concrete shall be totally isolated from flowing waters for a minimum curing period of 48 hours to allow the pH to reach neutral levels.

5. The Contractor shall control all water flowing through the Site of the Work to ensure such water does not become contaminated as a result of the Work.

6. The Contractor shall be responsible to ensure that all water exiting the area of his/her Work meets or exceeds Federal, Territorial or Municipal water quality standards for the activities being undertaken.

3.4 Air Quality

3.4.1 Dust and Air Pollution Measures:

1. The Contractor shall control dust emissions from the Work or activities incidental to the Work to the satisfaction of the Manager.

2. All equipment shall be fitted with standard emission control devices appropriate to the equipment and in compliance with Federal and Territorial regulations and standards.

3.4.2 Burning:

1. Burning of any material, except fuels in a piece of equipment designed to burn fuels, shall not be permitted except with the express written consent of the Manager.

2. All burning, as permitted above, shall be under the supervision of a responsible party at all times.

3. The Contractor shall have on-site suitable portable fire fighting equipment as approved by the Manager.

4. All burning shall be as specified by Federal and Territorial authorities. Valid permits and authorizations shall be obtained from the appropriate authorities and a copy of such shall be submitted to the Manager for any and all burning.

3.5 Wildlife and Wildlife Habitat

1. The Contractor shall avoid disturbance of wildlife and or disruption to wildlife habitat.

2. The Contractor shall use “wildlife-proof” garbage disposal containers for all food scraps, lunchroom scraps, and other wastes which might attract wildlife.

3. Feeding of wildlife, including, but not limited to, bears, birds, and small mammals, shall not be permitted.

4. Site specific wildlife interaction procedures found within the Diavik Diamonds Construction Health/Safety Plan shall be followed.

3.6 Heritage/Archaeological Resources

1. The Contractor shall conduct activities so that social, cultural and historical resources are protected.

2. Archaeological sites or other sites of historic or cultural significance shall be protected. Disturbance of such sites in any manner shall not be permitted except with the express written consent of the Manager and the responsible governing body.

3. The Contractor shall observe all regulations concerning public health and is responsible for providing sanitation facilities if required. Sanitary waste shall be taken to an approved disposal site as outlined in the Diavik Diamonds Construction Waste Management Plan.

4. The Contractor shall ensure that his/her workforce does not adversely impact adjacent communities or individuals.

3.7 Petroleum Products

1. Diesel fuel will be provided by others. The Contractor shall provide his own fuel trucks and obtain supplies at the main Fuel Storage Facility, as required.

2. Storage of other petroleum products by the contractor, including propane storage and lubricant storage shall be designed to meet or exceed the existing safety regulations of the appropriate Provincial/Territorial Petroleum Association, the National Fire Code, and the Workers' Compensation Board.

3. All personnel handling fuels shall be trained in contingency measures for spillage and leakage of fuels.

4. Contingency plans to deal with spillage or leakage of fuel shall consist of Contractor supplied absorbent materials as outlined in the Diavik Diamonds Construction Emergency Response Plan. These, and other requirements, shall be approved in writing by the Manager's Representative prior to the movement of petroleum products onto the Site of the Work.

5. Any spill of petroleum products by the Contractor greater than 0.5 litres shall be reported immediately to the Manager. Clean-up of such spills shall commence immediately by the Contractor. Reporting of petroleum spills to authorities shall be as set out in the appropriate legislation and regulations. Such reporting is the responsibility of the Contractor.

6. Waste fuel, oil, solvents, and other petroleum products shall be disposed of at an on-site location, which has been approved by the regulatory authorities as outlined in the Diavik Diamonds Construction Waste Management Plan.

7. Waste materials such as oil cans, grease tubes, spent filters, and oily rags shall be collected and properly disposed of on-site as outlined in the Diavik Diamonds Construction Waste Management Plan.

8. Service trucks shall be equipped with suitable spill containment equipment including absorbent pads, containers to hold oil contaminated soils, and oil absorbent materials which can be used to collect spilled oil for disposal.

3.8 Sandblasting

1. All areas to be sandblasted shall be shrouded in such as way that all materials being used in the sandblasting, with the exception of the compressed air, are collected.

2. Collected sand, paint chips, and corroded materials shall be disposed of in accordance with government regulations.

3. Shrouding for sandblasting shall control dust from coming in contact with workers (see Workers' Compensation Board Regulations) or the surrounding area.

4. Removal of shrouding shall be conducted in such a manner, that dust and materials, which have collected in the shrouding are not released to the environment.

5. Shrouding shall be constructed of such materials that the structure and shrouding can withstand normal wind and storm events encountered during the period of Work for the area. Shrouding which becomes torn and/or inoperative due to weather conditions, or construction accidents, shall be repaired prior to resuming Work.

3.9 Painting

1. The following shall apply to the storage and disposal of painting materials:

    - Materials used in painting shall be stored in such a manner that accidental release to the environment is prevented.

      Storage facilities shall be set back 75 metres from the high water mark of watercourses. The storage facilities shall be diked or otherwise contained so that a release of all stored materials will be contained within the dike.

      Storage facilities shall be well away from other buildings, petroleum storage facilities, and other combustibles.

      Storage facilities shall be protected with suitable locks and closures against vandalism and wildlife.

      Disposal of used brushes, rags, solvents, and other materials shall be to on-site facilities maintained by Diavik Diamond Mines Inc. consistent with local and territorial regulations and as outlined in the Diavik Diamonds Construction Waste Management Plan.

3.10 Restoration and Reclamation

1. The Contractor shall coordinate with the Manager and Site Services Contractor to ensure that all debris, waste, garbage and other materials not naturally found at the Site are removed at the completion of the Work, and that the Site is left in a neat and tidy condition satisfactory to the Manager.

2. All temporary structures shall be removed at the completion of the Work unless such facilities are required by the owner for future use.

3. Soils and/or other materials contaminated by petroleum products, chemicals or other undesirable materials shall be cleaned up to the satisfaction of the Manager. Materials so fouled shall be excavated and hauled to an approved disposal site as outlined in the Diavik Diamonds Construction Emergency Response Plan and Diavik Diamonds Construction Waste Management Plan, unless otherwise agreed in writing by the Manager's Representative. Areas so fouled shall be repaired and restored to the satisfaction of the Manager.

4. Sediments collected in sediment control traps shall be removed at the completion of the Work. Sediment control traps shall be similarly removed unless otherwise directed by the Manager. These materials shall be disposed of in a manner satisfactory to the Manager.

5. All Work areas, staging sites, storage areas and other sites disturbed during the conduct of the Work shall be restored as directed by the Manager.

3.11 Domestic Waste

1. The Contractor shall store domestic solid waste in containers provided for the purpose and dispose of sewage from portable latrines at locations and in a manner approved by the Manager.

-END OF SPECIFICATION

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1.0 GENERAL

1.1 Reference Standards

1. American Society for Testing and Materials (ASTM) Standards:

ASTM D3796-87	Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics: Diaphragm Bursting Strength Tester Method
ASTM D3797-80	Test Method for Bursting Strength of Knitted Goods: Constant-Rate-of Traverse (CRT), Ball Burst Test
ASTM D4355-84	Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
ASTM D4491-89	Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533-85	Test Method for Trapezoid Testing Strength of Geotextiles
ASTM D4595-86	Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
ASTM D4632-86	Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)
ASTM D475 1-87	Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4833-88	Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
ASTM D4884-90	Test Method for Seam Strength of Sewn Geotextiles

1.2 Environmental Protection

1. Comply with the requirements of Specification VM00467-31 20-41EF -0002 (Environmental Protection) and of the Water License.

1.3 Submittals

1. Submit detailed plan for turbidity barrier. The turbidity barrier shall include:

    - General arrangement and description
    - Details of method of transportation, handling and on site storage prior to deployment

- Description and Specification for materials and equipment including boats and lifting equipment
- Details of the deployment configuration and procedures
- Description and details of floatation, anchorage and mooring
- Details of maintenance
- Description of removal and storage procedures

2. Submit detailed design for turbidity barrier as shown on drawings. Design in accordance with criteria specified in this document and industry standards.

   Design shall include:

   - Design criteria
   - Design calculations
   - Design and shop drawings

1.4 Definitions

1. **Turbidity Barrier:** A configuration of curtain (polyester reinforced vinyl fabric), flotation system and anchorage, to control dispersion of suspended solids within the area enclosed by the barrier.

1.5 Design

1. Design turbidity barrier in accordance with the requirements specified herein to extend to a depth corresponding to 1 m above lakebed (except where water depth < 2 m) with a maximum depth of 19m as shown on the drawings.

2. Design the turbidity barrier to be installed in the lake when there is no ice.

3. Include in the design an anchoring system to hold the curtain in place against wind, wave and current forces while minimizing tearing due to wave action.

4. Include in the design connection details to provide a continuous barrier. Minimum distance between joints should be 30 m.

5. Include in the design a furling or reefing system to lift the curtain for movement in the lake, to adjust depth to suit lakebed bathymetry and for removal to storage.

2.0 PRODUCTS

2.1 General

1. Handle, store and protect all materials from deterioration and contamination. Do not use deteriorated or contaminated materials.

2.2 Curtain

1. Curtain fabric must meet the following minimum requirements:

    - Grab tensile strength: 130 lbs (578 N)
    - Puncture strength: 40 lbs (178 N)
    - Trapezoidal Tear: 60 LBS (267 n)
    - Burst Strength: 140 psi (965 kPa)
    - AOS (US Sieve Size): 70 sieve (210 micron)
    - Water flow rate minimum: 55 gpm/ft (37 l/s/m)

2. Seams in the fabric shall either be vulcanized, welded, or sewn and shall develop the full strength of the fabric.

2.3 Floats

1. Provide flexible, buoyancy units, contained in a continuous sleeve or collar attached to the curtain such that during high wave condition, the floats may move relative to the suspended portion of the curtain.

2. Provide flotation units sufficient to support the weight of the curtain and load lines and maintain a freeboard of at least 75 mm above the water surface and provide a buoyancy ratio (buoyant force/curtain weight) of at least five.

3. Provide flotation sleeves to meet the following requirements:

    - Grab Strength: 170 lbs (756 N)
    - Low Temp Bend: 55°F (-67°C)
    - Resistance: 70% after 2000 hrs

4. Floating portion of barrier to be in bright color (yellow or «international» orange are recommended) and acceptable to the Manager's Representative.

2.4 Mooring and Anchorage

1. Fabricate load lines into the top and bottom of the fabric.

2. Provide the top load line with sufficient break strength to support the load from the wind, waves and handling.

3. Provide bottom load line incorporated into the bottom hem of the curtain with sufficient weight to hold the curtain in vertical position.

4. Provide bottom anchors to hold the curtain in position.

5. Provide end anchorage sufficient to withstand all loads from the barrier.

3.0 EXECUTION

3.1 Deployment

1. Provide barrier folded, for easy extraction at deployment and placed in containers.

2. Select a location to manipulate the curtain ashore free of sharp rocks, debris or other material which may damage the barrier. Alternatively, prepare a working area for same purpose.

3. Install the barrier on the alignment shown on drawings.

4. Install end anchorages.

5. Position turbidity barrier and attach end anchorages and intermediate anchors as required.

6. Unfurl barrier.

7. Limit depth of barrier to 1 m above lakebed or depth as required by Manager's Representative. Barrier may be grounded in shallow areas (see drawings).

3.2 Removal

1. Prior to removing the barrier from the water, furl the barrier.

2. Exercise care when the barrier is being brought ashore to protect the skirt and flotation sleeve from damage.

3.3 Maintenance

1. Make periodic inspection of the barrier to ensure effective operation.

2. Provide all material and labor necessary to perform repairs to the barrier.

3. Store barrier for re-use by folding the barrier in «accordion style» and cover with opaque plastic sheets.

4.0 QUALITY CONTROL

4. Report

- Submit coordinates of actual barrier alignment.
- Submit post-construction report indicating material types used and corresponding quantities.

-END OF SPECIFICATION

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1.0 GENERAL

1.1 Submittals

1. .Submit a detailed dredging plan. The dredging plan shall include:

   – Description, specifications and condition of equipment.
   – Description and specifications of equipment to continuously monitor the slurry density on a real time basis.
   – Description of location control equipment and methodology.
   – Construction methods and procedures including technique and equipment specifications for identifying remaining lake sediment and acceptable foundation.
   – Minimum depth of water for dredging operation.
   – Specific details of dredging equipment and methods to minimize suspended solids in the lake water caused by the dredging operation and to ensure compliance with environmental restrictions.
   – Power supply.
   – Safety plan.
   – Plan for refuelling, servicing, re-crewing dredge during operation.
   – Contingency plan for dealing with fuel and lubricant leaks and spills of dredged material.
   – Plan for dealing with stoppages in cold weather to prevent freezing of pipelines.
   – Quality control plan.

2. Submit detailed design for pipelines from point of dredging to disposal area. Design in accordance with the following points and industry standards.

3. .Design shall include:

   – Design calculation for all pipework.
   – Pipeline road crossings.
   – Outlet pipeline structure at on land containment facility. Concrete thrust blocks at changes in pipeline direction. Concrete bases for auxiliary pumps and other equipment.
   – A plan for the disposal of sediment into the ponds

4. Submit trial dredging plan if required.

1.2 Requirements of Regulatory Agencies

1. Comply with territorial and national codes and regulations.

1.3 Survey Datum

1. Reference location control to horizontal and vertical survey datum provided by Manager's Representative. The work shall be laid out using the station and offset method from this reference point.

1.4 Floating Plant

1. Dredges or other floating plant to be employed on this Work, to be of Canadian registry, make or manufacture, or, must receive certificate of qualification from Industry, Science and Technology Canada.

1.5 Site Information

1. Geotechnical investigations including soundings, drill holes, geophysical surveys and site topographical surveys have been carried out on site and are available for viewing in Yellowknife.

2.0 PRODUCTS

Not used.

3.0 EXECUTION

3.1 General

1. Mark floating equipment with lights in accordance with Transport Canada Ship Safety and maintain radio watch on board or as directed by Manager's Representative.

2. Place and maintain buoys, markers and lights required to define Work.

3. Lay out Work from benchmarks and base lines established by Manager's Representative. Be responsible for accuracy of Work relative to established benchmarks and baseline. Provide and maintain electronic position fixing and distance measuring equipment, laser transits and such other equipment as normally required for accurate dredging control.

3.2 Trial Dredging Program

1. A dredging trial is required in the event that the subcontractor and the cutter suction dredge are other than those used for the A154 and A418 dikes.

2. Select an area for trial dredging on the A21 dike footprint where the water depth is at least 5 m. The area should cover the equivalent of the full sweep width intended for production dredging and two full spud carriage advances.

3. Diver inspection of the area with video camera coverage to be performed prior to dredging.

4. Perform necessary number of passes (according to sediment thickness) to reach till or other acceptable foundation.

5. A diver inspection to establish thickness of residual fluff shall then be carried out and instructions for additional dredging will be transmitted if required.

6. Perform additional passes to remove fluff to less than 10 cm average depth.

7. Prepare and submit report describing findings and modifications to dredging procedures which are planned for the production dredging. Include measures deemed necessary to meet total suspended solids (TSS) restrictions.

3.3 Dredge Requirements

1. The dredging limits and depths shown on the drawings are approximate and may be revised in the field by Manager's Representative.

2. Remove lake sediment to depths and limits indicated on the drawings or as modified by the Manager's Representative based on the trial dredging program, actual site conditions and pre/post dredge surveys.

3. The intent of the dredging is to remove the lakebed sediment down to acceptable foundation such as consolidated sediments, dense till or dense granular materials, to the acceptance of

Manager's Representative. Acceptable foundation is defined as a firm base, which can be detected by the dredge master from cutter head response. Lakebed sediments and fine uniform sand will be required to be removed from the dike footprint. Additional dredging along the cutoff axis or in areas of deep sediments may be required. The extent will defined from piezocone soundings performed prior to construction. The use of a clamshell or submersible pump with mechanical and water jet agitation may be required.

4. The technique proposed by the dredge contractor for identifying the upper boundary of the dense material will be reviewed after the execution of the trial dredging program or after the initial production work.

5. Residual fluff to a depth of 10 cm will be permitted on the footprint of the Zones 1A/1C filter blankets and 20 cm on the footprint of the upstream Zone 3 shoulder.

3.4 Surveys

1. Geophysical surveys have been carried out over the dike footprint and these form the basis of the pre-dredge bathymetric plots.

2. Diver's inspections shall be carried out along alignments marked by a system of ropes positioned on the lake bed in order to locate the diver's observations in terms of stations and offsets. The inspections shall proceed in a sweeping manner on both sides of the rope alignments to entirely cover the dredged surface area.

3. The diver shall measure by hand probing the thickness of residual sediment. Tin can samples shall be taken on minimum 15 m intervals along the dike axis and at specific locations if required by Manager's Representative.

4. A diver's report summarizing the inspection findings (remaining sediment, boulder nests, etc) shall be submitted to Manager's Representative. The diver shall be available for debriefing sessions if required.

5. The sediment thickness isopach drawings have been developed from the above bathymetry, the sediment/consolidated deposit boundary reflector, piezocone soundings and drill hole information.

6. Develop a dredging plan (type of equipment/schedule) based on his interpretation of the same data sources.

7. Carry out a post dredging geophysical survey and produce as-built drawings consisting of survey profiles run transversally to the dike axis at intervals of 5 m maximum and a plan locating the profiles.

3.5 Acceptance of Work

1. Manager's Representative will review the survey data, diver reports, in- situ measurements of residual sediment thickness, logs of dredged material and samples taken by divers and determine if additional dredging is required. Contractor is to perform the work to the revised limits.

3.6 Disposal of Dredged Material

1. Dispose of dredged material by depositing in the sediment pond, at the area and in a manner approved by Manager's Representative and no closer than 10 m from the containment or filtration dams.

3.7 Dredge Slurry Pipeline

1. The dredge slurry pipeline shall be constructed on the right of way constructed for this purpose.

2. The route of the right of way is indicated on the drawings.

4.0 QUALITY CONTROL/QUALITY ASSURANCE

See QA/QC Plan document.

-END OF SPECIFICATION

AMEC EARTH & ENVIRONMENTAL	Technical Specification **MATERIAL PREPARATION & BLASTING**	Revision	
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1.0 GENERAL

1.1 Related Specifications

Specification	Title
VM00467-14300-41ES-1006	Embankment for Dikes
VM00467-14300-41ES- 1012	Plastic Concrete Cutoff Wall
VM00467-14300-41ES- 0001	Site Conditions

1.2 Environmental Protection

1. Comply with the requirements of Specification VM00467-14300-41ES -0002 (Environmental Protection) and of the Water License.

1.3 Quarry Rock Supply

1. No Quarry operation is required. A stockpile of mine rock will be placed at the contractors disposal for the production of all rock products for dike construction.

1.4 Submittals

1. Submit:

   a.) equipment and material lists for quarry and crusher operations,

   b.) crusher management plan for construction materials Zones 1, 1A, 1B, 1C, 2, 6 and plastic concrete fine and coarse aggregates,

   c.) stockpile construction, use and management,

   d.) quality control plan.

1.5 Permits and Regulation

1. The Contractor shall obtain all necessary permits for, and shall comply fully with the laws, rules and regulations of Municipal, Territorial and Federal agencies in connection with the use, transport, storage and safe handling of all explosives, including those regulations contained in the Mine Health and Safety Act of the Government of the Northwest Territories.

1.6 Insurance Coverage

1. No blasting shall be conducted prior to the receipt by the Manager's Representative of the Certificates of Insurance required under the Contract. The Certificates shall verify that the Contractor's General Liability and Property Damage Coverage contains no specific exclusions for work related to blasting.

1.7 Limitation and Liability

1. The Contractor shall be held responsible for all costs resulting from any blasting related damage or injury.

2.0 MATERIALS AND PRODUCTS

2.1 Materials

1. All products and materials used for blasting operations shall be from a recognized supplier and shall be products of a company regularly engaged in the manufacture of explosives and related products.

2. Explosives with an expired shelf life shall not be used.

3. The use of electric blasting caps will not be permitted.

2.2 Products

The following construction materials are required for the earthworks: Zones 1, 1A, 1B, 1C, 2, 3 and 6 materials, in accordance with Specification VM00467-14300-41ES-0006 and plastic concrete aggregates in accordance with Specification VM00467-14300-41ES-0012.

3.0 EXECUTION

3.1 Blasting for Dike Foundation Preparation

1. No blasting or rock excavation shall proceed until the plans for the area have been reviewed and approved by the Manager's Representative.

2. Approval by the Manager's Representative of the blasting plan shall in no way relieve the Contractor from the responsibility for ensuring that the blasting operation is conducted in a satisfactory manner and in accordance with these specifications, nor shall the Manager's Representative assume any responsibility for the adequacy of the blasting to achieve adequate breakage or acceptable results or for any damage to structures, equipment and personnel.

3.1.1 Preparation

1. Dispose of unsuitable materials as directed by the Manager's Representative.

2. Slopes in soil and rock shall be constructed such that they will remain stable during and following excavation.

3. The Contractor shall provide open ditches and sedimentation ponds, as required, to control runoff and prevent silty water from flowing into streams, ponds or Lac de Gras in accordance with specification VM00467-14300-41ES-0002 – Environmental Protection and of the Water License.

3.1.2 Notifications

1. The Contractor shall ensure that the Manager's Representative receives a Notification of Blasting a minimum of forty-eight (48) hours in advance of blasting.

2. The Notification of Blasting shall contain details of the location, time and size of the blasting, and any proposed departures from the previously submitted blasting plan.

3. The Contractor shall ensure that all site personnel, including other contractors, are notified of the approximate period of blasting at least twenty-four (24) hours in advance of the first blast, and of the planned blasting schedule

4. Final authorization to proceed with blasting shall be given by the Manager's Representative when he is satisfied that all necessary precautions to prevent damage to structures, equipment and personnel are implemented.

3.1.3 Personnel

1. The Contractor shall provide at least one person thoroughly trained and experienced in the use of explosives who shall be present at all times during the execution of any blasting operation and who shall direct such work.

2. The Contractor shall ensure that no person is allowed to conduct any task related to a blasting operation unless he is the holder of a valid Blaster's Certificate issued by the Government of the Northwest Territories, or under the direct supervision of a certificate holder, if permitted by the authorities having jurisdiction.

3.1.4 Safety

1. The Contractor shall perform the Work in a manner to prevent injury or harm to any personnel employed in the area of a blasting operation by posting warning signs, conducting a sweep of the area affected and by using readily recognizable audible warning signals in accordance with the Mine Health and Safety Act of the Government of the Northwest Territories.

3.1.5 Ground Vibration

1. The Contractor shall utilize excavation and blasting methods designed to limit the intensity of ground vibrations emanating from the excavation, such that the peak particle velocity shall not exceed 50 mm/s measured at nearby existing facilities or structures.

2. Upon request by Manager' Representative, the Contractor shall provide instrumentation and conduct vibration measurements during all blasting. The results of the vibration monitoring shall be made available to the Manager's Representative. If the Manager's Representative advises that deficiencies are observed during any blasting operation they shall be corrected immediately.

3.1.6 Flyrock

1. The Contractor shall exercise extreme care to prevent flyrock. Matting, consisting of steel cables and rubber tires, shall be used where appropriate. Blasting mats should be properly weighted as required.

3.1.7 Site Clean-Up

1. The Contractor shall dispose of all debris from his blasting operation including all explosive packaging materials as directed by the Manager's Representative.

2. Explosives, caps, and any other consumable items that have not be used, shall be removed from the site and disposed of or stored by the contractor, as required by the regulatory authorities.

3.2 Crusher Management Plan

1. At least 3 months prior to commencing the installation of the crusher plant, the Contractor shall submit to the Manager's Representative a crusher management plan which shall include the following information:

    - A description of the equipment and manpower which will be used for crushing, screening blending and stockpiling the required dike construction materials Zones 1, 1A, 1B, 1C, 2

and 6 and plastic concrete aggregates. Provide a summary of relevant experience for key field personnel who will supervise these operations.

- Stockpile location plan for approval by Manager's Representative including drainage, collection and control of runoff from the stockpiles.

- The methods for processing and handling crushed materials to prevent contamination, segregation or degradation.

- The blending methods to produce the required materials. Blending methods and equipment shall be approved by Manager's Representative.

- Expected production rates and contingency plans in the event that production rates are lower than expected.

- A simple bar chart schedule, which demonstrates how the various milestone dates will be achieved.

3.3 Stockpiling Requirements

1. The stockpile site shall be prepared such as to ensure that conditions regarding ground levelling, drainage, bearing capacity, contamination at base level and intermixing of adjacent piles are adequate.

2. Dumping of Zone 3 and crushed stone materials in stockpile areas shall be carried out in lifts not exceeding 3 m and 1 m in height respectively. Re-excavation of stockpiled materials shall be done with equipment and methods which ensure adequate mixing of materials.

3. Coning of piles or end dumping material over the edges of a stockpile will not be permitted because it causes segregation. Dozing of materials across the stockpile surface will not be permitted if segregation is apparent.

4. If material production and stockpiling takes place during the winter months, incorporation of snow, ice and frozen material into the stockpiles may occur. The contractor shall take all reasonable precautions to minimize incorporation of snow, ice and frozen material.

5. Methods shall be used, as required, to avoid the freezing of Zone 1 material and plastic concrete aggregates stockpiled during rainy periods in late season. If the pile is frozen, other methods shall be used to thaw the pile and/or eliminate frozen lumps.

6. The stockpile areas are to be left in a tidy, well drained condition, free of standing surface water. Unused materials shall be shaped into compact heaps as directed by Manager's Representative.

4.0 QUALITY CONTROL

Refer to the QA/QC plan document.

-END OF SPECIFICATION

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1.0 GENERAL

1.1 Reference Standards

American Society for Testing and Materials

a) ASTM D422 Standard Test Method for Particle- Size Analysis of Soil

1.2 Environmental Protection

1. Comply with the requirements of Specification VM00467-14300-41ES-0002 (Environmental Protection) and of the Water License.

1.3 Submittals

1. Submit dike fill placement plan including:-
   - access plan and haul routes;
   - placement sequence;
   - placement methods;
   - survey methods (underwater and on-land works);
   - procedures for monitoring placement of Zones 1, 1A, 1B, 1C, 2, and 3 materials;
   - staffing and execution plan to meet QC requirements in Part 4 of this specification:
   - list of major equipment with rated payload capacities;
   - plans for interfacing with cutoff wall, grouting, and other dike construction activities;
   - preventative measures to avoid fuel/oil spills from barge mounted equipment.
   - safety features and policies for dozer operators, such as spare air tanks, removable rear windows, mandatory use of inflatable personal flotation device (PFD), and seat belt cutters.
2. Submit survey methodology and techniques for:
   - setting out the dike axis;
   - control and survey of fill placed on lake bottom;
   - survey of underwater dike slopes at the leading edge;
   - on-land surveys.

2.0 PRODUCTS

2.1 Dike Materials

1. Rock material for dike construction shall be obtained from A154 mine waste rock stockpiled by DDMI in designated areas. Stockpiles consist of shot rock up to 2 m in diameter randomly distributed in piles.

2. Select, load, haul to crushing plant, process and stockpile products in designated areas and/or incorporate directly in embankments

3. Material used for dike not to contain organic matter, frozen lumps, ice, weeds, sod, roots or other unsuitable material.

4. Rock containing biotite schist shall be placed only in Zone 3 at least 2m below low water level. Elsewhere, rockfill shall not contain more than 2% of biotite schist. DDMI is responsible for identifying rock materials that exceed the 2% criterion and providing that information to the Contractor for planning purposes. However, the Contractor shall also informally monitor DDMI-supplied rock materials by visual means and advise DDMI of any suspected mischaracterizations.

5. Zone 1 and Zone 1A - Only well graded crushed product conforming to the following gradation limits will be acceptable:

Sieve Size (mm)	Percent Passing by Weight
56	100
20	60-100
5	25-50
1.25	0-17
0.50	0-10
0.080	0-2

A fines content (fraction smaller than 0.08 mm) up to 4% by weight is acceptable for individual Zone 1 and Zone 1A gradation tests, provided the rolling average of five (5) successive tests for each zone type remains at or below 2%.

6. Zones 1B and 1C – Only well graded crushed product conforming to the following gradation limits will be acceptable:

Sieve Size (mm)	Percent Passing by Weight
56	100
20	60- 100
5	25-50
1.25	0-25
0.50	0-17
0.080	0-5

A fines content (fraction smaller than 0.08 mm) up to 7% by weight is acceptable for individual Zones 1B and 1C gradation tests (for material placed in the wet), provided the rolling average of five (5) successive tests for each zone type remains at or below 5%. For Zone 1B placed in the dry (above El. 417.5 m), an average fines content of up to 7% shall be acceptable.

7. Zone 2 - Only well graded crushed product conforming to the following gradation limits will be acceptable:

Sieve Size (mm)	Percent Passing by Weight
200	100
100	60- 100
75	45-92
50	30-77
20	10-45
10	0-30
5	0-18

8. Zone 3 - Only rock fill conforming to the following gradation limits will be acceptable:

Sieve Size (mm)	Percent Passing by Weight
900	100
300	40- 100
100	20-55
20	0-27
10	0-20
2.5	0-10

3.0 EXECUTION

3.1 Preparation

1. Place dike materials after removal of lakebed sediment, excavation of boulders nests where required and inspection and acceptance of foundation in writing by Manager's Representative.

3.2 Placement of Embankment

1. Place Zones 1, 1A, 1B, 1C, 2, and 3 materials to lines and grades as indicated on the drawings and as directed by Manager's Representative.

2. Begin embankment construction in vicinity of north and south abutments and advance outwards.

3. a) Place Zones 1A and 1C using crane mounted skip or clam shell operated from a barge in deep water conditions or using back hoe in shallow water conditions or by other similar technique.

   b) Do not dump Zones 1A and 1C through water or allow Zones 1A and 1C materials to fall through water more than 0.5 m to prevent material segregation.

   c) Place blanket material to minimum distance of 2 m beyond the theoretical downstream toe of embankment placed in the wet.

4. Use DGPS survey technology to ensure that load by load placement of Zones 1A and 1C fill materials by skip or clamshell in a grid manner permits the construction of a uniform blanket satisfying the requirements shown on the drawings.

5. Using ultrasonic echo sounding technique, survey the upper surface of the blanket along alignments spaced on maximum 5 m intervals and run transversely to dike axis. Compare results with post-dredged surveys to demonstrate blanket thickness. Prepare plans and profiles of survey lines showing blanket thickness, dike outer envelope, dike axis and offsets marks on 5 m intervals.

6. As and when requested by Manager's Representative, verify the uniformity of the blanket surface by depth soundings (i.e. 300 mm x 300 mm steel plate attached to a rope) coupled with DGPS surveys. Plot results to demonstrate that the required Zone 1A blanket thickness is obtained everywhere including between points of skip/clamshell unloading. Adjust load placement method as required to satisfy requirements.

7. Obtain written approval from Manager's Representative for each surveyed blanket profile prior to undertaking placement of overlying materials.

8. Load, haul, dump, place and spread Zones 1, 1A, 1B, 1C, 2, and 3 materials in such a manner as to minimize segregation and provide a homogenous well-graded embankment.

9. Underwater placement of Zones 1, 1B, 2 and 3 to be carried out by dumping on the dike working platform (which can vary from El. 416.5 to 417.0 at the Contractor's discretion) close to the leading edge in order to advance Zones 1/1B, 2 and 3 simultaneously. Push the materials forward with a dozer and then, approximately 1 m from the leading edge, in a downward manner to induce a slip displacement and minimize the rolling segregation of the materials. Zones 1 and 1B to generally lead adjacent Zones 2 and 3 to maintain the contact between adjacent zones at the theoretical line or within tolerances.

10. In curved segments, adjust the advance of each zone front at the leading edge so as to maintain the lateral location of the contacts in relation to dike axis as per the requirements. Perform echo sounding surveys as indicated in the following section to confirm the conformity of the internal zoning or the need to adjust the placement method.

11. Do not place any Zones 1A/1C material within 100 m of un-dredged lakebed sector, measured along the dike alignment. Where clamshell or dragline removal of sediments is used, or monitoring of TSS measurements during marine dredging operations indicate acceptable levels, this restriction may be revised with the approval of Manager's Representative.

12. Do not place any Zone 1, 1B, 2 and 3 materials within 50 m from the advancing Zones 1A/1C placement front.

13. Vibrodensify Zones 1 and 1B materials from the working platform as shown on drawings and per specification VM00467-14300-41ES-0007.

14. Compact Zones 1B, 2 and 3 at working platform after completing vibrodensification with 4 passes of smooth drum vibratory roller specified below.

15. Place fill at Zones 1B, 2, and 3 above the elevation of the working platform and at the downstream toe of the dike after dewatering, in layers of thickness according to Table 1 before compaction and compact with 4 passes of the "Ingersoll-Rand" SD- 180D or equivalent smooth drum vibratory roller having the following characteristics:

    - Total weight: 18 tonnes
    - Weight at drum: 11 tonnes
    - Frequency: 1300 - 1825 v.p.m.
    - Centrifugal force: 360 kN

Table 1: Maximum Permissible Layer Thickness

Zones	Max. Particle Size (mm)	Layer Thickness before compaction (mm)
1	56	500
2	300	500
3	900	1000

16. A pass is considered to have been completed each and every time a compactor passes over a given point with the specified weight and vibratory energy, whether traveling forward or backward.

17. Push large pieces of Zone 3 material to outside of section to create a riprap zone. Riprap rock pieces need not be placed individually, but shall be levelled and dressed to ensure the completed face is stable with no tendency to slide, and that there will be no unreasonably large voids.

18. Monitor placement of fill materials to avoid unacceptable conditions, including but not limited to:

    - concentrations of cobbles and boulders except in the riprap zone;
    - soft foundation material and accumulation of lakebed sediment;
    - deviation from lines, grades and material thickness as shown on the drawings;
    - evidence of bulging, slumping, sloughing, or material losses during placement;
    - displacement of Zone 1A blanket or Zone 1C blanket by subsequent overlying fill placement.

    Remove unacceptable materials and replace with material conforming to the specification requirements and adjust method of placement to prevent further occurrence.

19. In certain areas of the foundation (steep slopes) additional Zone 1A and/or Zone 2 material may be required to be placed by clamshell to build a stabilization berm prior to dumping rockfill and avoid embankment slope instability that could result in rupture of Zone 1A/1C blanket. Additional material may also be required in the deepest part of the foundation to raise the central platform (± 5 m from centerline).

3.3 Dike Alignment and Slope Adjustment

1. Control embankment alignment using DGPS surveys.

2. The slopes of rockfill dumped underwater have been estimated and may vary. The final average outer slope of the upstream shell (above elevation 416.5 m only) and the downstream shell (full height) must be 1.6H:1.0V and 1.7H:1.0V respectively, or angle of repose if flatter. Regrade to achieve this minimum average slope. Remove overbuild on the outer slopes above elevation 416.5 m prior to dewatering. Overbuild on the upstream face may be left in place below elevation 416.5 m. Remove overbuild on the downstream face below 416.5 m after dewatering.

3. The slopes between adjacent dike zones dumped underwater are specified on drawings. Survey the underwater embankment slopes at the leading edge using echo sounding devices operated from a stable boat. Initially perform surveys daily to develop and adjust method and sequence of fill placement that allows the specified contact slopes to be obtained, including in curved segments. Execute surveys along lines spaced on regular intervals parallel and perpendicular to dike axis.

4. Prepare contour plans and profiles of the leading edge with a view to determining the underwater slopes in each material zone and locating the trace of the contacts along the plane of the leading edge. The frequency of surveys may subsequently be reduced with the approval of Manager's Representative after the construction method has been demonstrated to give satisfactory results.

5. Using the above mentioned underwater survey results or manual depth soundings, verify that no significant bulging occurs at the toe of the leading edge slope, which can be synonymous with rupture of the blanket by sliding of the embankment. Adjust construction method as and when required by Manager's Representative.

3.4 Protection of Existing Thermistors

1. Locate, remove, salvage, and turn over to DDMI as many existing thermistor cables only as deemed reasonably possible as discussed and agreed to on a case by case basis with the Manager's representative.

2. Salvaged thermistor cables shall not be reused in the A21 permanent works unless directed by Manager's Representative.

4.0 QUALITY CONTROL

Refer to the Quality Control/Quality Assurance Plan document.

-END OF SPECIFICATION

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1.0 GENERAL

1.1 Submittals

1. Submit a vibro-densification plan that must include:

    - Detailed list of equipment, condition and model numbers and number of probes.
    - Proposed sequence of work and detailed procedures.
    - Densification log form.

1.2 Qualifications

1. Vibro-densification contractor shall be experienced in the vibroflotation process for subsurface conditions similar to those of this project. Submit case histories of densification for similar projects.

2.0 PRODUCTS

2.1 Backfill

1. Zone 1B material as specified in VM00467-14300-41ES -0006.

3.0 EXECUTION

3.1 Equipment

Furnish vibratory units and ancillary equipment of a size and capacity to fully penetrate 25 m of crushed rockfill of which the maximum particle size is 56 mm. The vibratory units shall be electrically driven.

High pressure flushing water ejected at the probe tip is a necessity.

3.2 Layout

1. Layout the penetration pattern using a 2.5 m spacing and mark the location of each hole with wooden stakes or painted rock fragments.

3.3 Trial Densification

1. Prior to start of densification and if using equipment other than that employed for the construction of the A154 or A418 dikes, perform trial densification at location designated by Manager's Representative, to demonstrate performance of the equipment, verify spacing and depths of the penetrations.

2. Trial Densification Section shall be a minimum of 50 m long and may be incorporated in the permanent densification work. Load counts of material (Zone 1B) added to compensate for densification-induced depressions shall be kept to provide parallel record of densification achieved. Loads will be tracked for 10 m increments along the axis of the dike.

3. After densification perform a minimum of 10 Becker penetrometer tests, or equivalent as approved by the Manager's representative, to the full depth of the dike to determine the effectiveness of the densification.

4. If specified penetration resistance is not achieved, adjust equipment settings, rate/length of withdrawal and penetration spacing and perform further trial densification until penetration resistance is achieved. Note that the objective is to obtain a relative density of at least 70%. Previous work has indicated that this corresponds to a corrected blow count of about 20. Nine out of ten results shall have a minimum blow count of 20 and the exceptional results shall be no less than 15.

3.4 Densification

1. Perform densification in Zone 1 and Zone 1B crushed stone from dike working platform at El. 417.5, to the dike foundation and to the limits shown on the drawings. Add Zone 1B crushed stone as required and record the size and number of loader buckets added to form each column.

2. Hole locations falling on the Zone 1/1B to Zone 3 and Zone 1/1B to Zone 2 interfaces may be relocated 0.5 m away from the said interfaces to avoid encountering rock fragments.

3. While injecting water under pressure at the probe tip, vibrate the probe to the foundation elevation. Perform densification by alternatively withdrawing and allowing the probe to settle in increments of 0.5 to 0.75 m until the maximum hydraulic pressure or amperage of the equipment has been reached and then proceed to the next increment.

4. If the dike fill in the upper part of the working platform is frozen, remove frozen material and replace with new Zone 1B fill.

5. Injection of air in lieu of water during freezing conditions is not an acceptable alternative.

6. Perform densification until a minimum corrected Becker blow count of 20 per 30 cm is obtained for the full depth of the dike.

7. Corrected blow counts are obtained after correcting for both the bounce chamber pressure recorded for each 30 cm increment and the confining pressure whose correction factor C_n varies as a function of depth according to the relationship developed by Liao and Whitman, with a maximum value of 1.7:

$$C_n = \left(\frac{100}{\sigma'_{v_0}} \right)^{1/2}$$

8. If the specified value is not achieved, perform a sufficient number of test holes to define area requiring re-densification.

9. Re-densify areas which do not achieve the specified requirement.

10. Manager's Representative will witness Becker penetration tests.

11. Do not perform vibro-densification within 50 m from the advancing Zones 1, 1B, 2 and 3 placement fronts.

4.0 QUALITY CONTROL

As per the QA/QC plan document.

END OF SPECIFICATION

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1.0 GENERAL

1.1 Reference Standards

1. American Society for Testing and Materials.

    a) ASTM C203, Test Methods for Breaking Load and Flex and Properties of Block-Type Thermal Insulation.

    b) ASTM C273, Method for Shear Test in Flatwise Plane of Flat Sandwich Construction or Sandwich Cores.

    c) ASTM C 177, Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.

    d) ASTM C518, Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.

    e) ASTM D696, Test Method for Coefficient of Linear Thermal Expansion of Plastics.

    f) ASTM D1621, Test Method for Compression Properties of Rigid Cellular Plastics.

    g) ASTM D1623, Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics.

    h) ASTM D2842, Test Method for Water Absorption of Rigid Cellular Plastics.

    i) ASTM E96, Test Method for Water Vapor Transmission of Materials.

2. Canadian General Standards Board.

    a) CAN/CGSB-5 1.20, Thermal Insulation, Polystyrene, Boards and Pipe Covering.

1.2 Submittals

1. Technical data sheet of product.

2. Installation procedure

2.0 PRODUCTS

2.1 Materials

1. Insulation

Expanded polystyrene: to CAN/CGSB- 51.20, Type 4, insulation thickness to be 200 mm except where otherwise indicated on drawings, shiplapped edges. Spray-on insulation types may be proposed in lieu of polystyrene provided an equivalent degree of thermal protection is achieved.

- Minimum compressive Strength of 275 kPa when tested in accordance with ASTM D1621.
- Average Tensile Strength of 480 kPa when tested in accordance with ASTM D1623.
- Average Shear Strength of 275 kPa when tested in accordance with ASTM C203.
- Average Flexural Strength of 860 kPa when tested in accordance with ASTM C203.
- Minimum thermal resistance of 0.87 m^2°C/W as measured on a 25 mm thickness of insulation in accordance with ASTM C518, C177.
- Linear thermal coefficient of expansion, 0.063 mm/m/C°, in accordance with ASTM D696.
- Maximum water vapor-permeance, 35 ng/Pa.sec.m^2 in accordance with ASTM E96.
- Maximum water absorption, 0.7% by volume, in accordance with ASTM D2842.
- Maximum operating temperature, 74°C.

2. Bedding and cover Materials

a) Bedding Material: Zone 1B crushed stone as specified in VM00467-14300-41ES-0006.

b) Cover Material: Zone 2 rockfill as specified in VM00467-14300-41ES-0006.

3.0 EXECUTION

3.1 Installation

1. Place a 150 mm thickness of Zone 1B crushed stone as bedding for the insulation.

2. Bedding material must be graded smooth with a maximum surface elevation variation of no more than 25 mm over a 1.0 m distance.

3. Do not place insulation until base bedding material has been approved by Manager's Representative.

4. Install insulation to the lines, grades and elevations indicated or directed.

5. Install insulation to maintain continuity of thermal protection.

6. Cut and trim neatly to fit spaces, butt joints tightly. Use only insulation boards free from chipped or broken edges. Use largest possible dimension to reduce joints.

7. Place insulation in staggered fashion with long axis parallel to the dike centerline.

8. Do not backfill insulation until approved by Manager's Representative.

9. Immediately following placement of insulation, place a 500 mm thickness of Zone 2 material over the insulation, taking precautions not to damage insulation.

10. Do not allow heavy construction equipment on the insulated area prior to placement of 350 mm thick of Zone 2 rockfill.

11. Prevent damage to exposed and buried insulation at all times during construction.

12. Cover stockpiled insulation expected to be exposed to the atmosphere for more than three days with opaque plastic sheets.

4.0 QUALITY CONTROL

Refer to the QA/QC plan document.

-END OF SPEC IFICATION

AMEC EARTH & ENVIRONMENTAL	Technical Specification **EXCAVATING, TRENCHING & BACKFILLING**	Revision	
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1.0 GENERAL

1.1 Definitions

1. Excavation Classes:

   a) **Common excavation (in the dry):** excavation of materials of whatever nature, which are not included under definition of rock excavation, and carried out on land.

   b) **Common excavation underwater:** excavation of materials of whatever nature, which are not included under definition of rock excavation, carried out underwater by means of conventional methods.

   c) **Rock excavation:** excavation of material from solid masses of igneous, sedimentary or metamorphic rock which, prior to its removal, was an integral part of the parent mass, and boulders or rock fragments having individual volume in excess of 2 m^3. Excavation of boulders underwater will also be required.

   d) **Frozen overburden:** excavation of frozen overburden in permafrost zones.

1.2 Environmental Protection

1. Comply with the requirements of Specification VM00467-14300-41ES-0002 (Environmental Protection) and of the Water License.

1.3 Submittals

1. Submit details of proposed construction dewatering, such as cofferdams, pumping systems, well points, sump and ditches, sheet pile cut-offs or other means to achieve excavation along the downstream toe of the dike after dewatering.

2.0 PRODUCTS

2.1 Materials

2. Backfill

a) Zones 1B, 2, and 6 materials as shown on drawings and in accordance with requirements of Specification VM00467-14300-41ES-0006.

b) Concrete sand in accordance with Specification VM00467-14300-41ES-0011.

3.0 EXECUTION

3.1 Foundation Preparation

1. Remove obstructions, ice and snow, vegetation, organic soils, frost disturbed, saturated overburden and flow slide material from surfaces within limits indicated on drawings to acceptable foundation and as directed by Manager's Representative.

2. Remove surface exposed boulder nests from areas to be covered with Zones 1, 1A, 1B and 1C materials including areas underwater.

3. Boulders embedded in a soil matrix that will not be surrounded by significant voids after placement of fill need not be removed if approved by Manager's Representative.

3.2 Cofferdams

Construct temporary cofferdams to heights and locations as required for work.

3.3 Dewatering and Heave Prevention

1. Keep excavations free of water while work is in progress.

2. Do not excavate below groundwater table if a "quick" condition or heave is likely to occur. Prevent piping or bottom heave of excavations by lowering groundwater to at least 1.0 m below bottom of excavation, by sumps, well points, sheet pile cut-offs, or other means.

3. Protect open excavations against flooding and damage due to surface run-off.

4. Dispose of water in a manner not detrimental to any portion of the work completed or under construction or to the environment.

3.4 Excavation

1. Excavate to lines, grades and dimensions as indicated on Drawings or as directed by Manager's Representative.

2. For excavation of toe trench, prepare a profile along the trench axis indicating the ground level and the proposed toe drain trench invert required to achieve drainage to the pump stations, as indicated on drawings. Submit for approval by Manager's Representative prior to installing toe drain.

3. Dispose of surplus and unsuitable excavated material on site as directed by Manager's Representative.
4. Do not obstruct flow of surface drainage or natural watercourses which drain to the exterior of the A21 diked enclosure.

5. Earth bottoms of excavations to be undisturbed soil, level, free from loose, soft or organic matter.

6. Notify Manager's Representative when bottom of excavation is reached.

7. Obtain Manager's Representative's approval of completed excavation in writing.

8. Remove unsuitable material from trench bottom to extent and depth as directed by Manager's Representative.

9. Possession of written approval will not remove the obligation to carry out additional excavation if the foundation deteriorates between time of excavation and fill placement.

3.5 Fill Types and Compaction

1. Use fill types as indicated on drawings and in accordance with Specification VM00467-14300-41ES-0006.

3.6 Bedding and Surround of Underground Services

1. Place and compact Zone 1B and/or concrete sand bedding and surround of underground services as indicated on drawings.

2. Place bedding and surround material in unfrozen condition.

3.7 Backfilling

1. Use vibratory compaction equipment to achieve requirements of Specification VM00467-14300-41ES-0006.

2. Do not proceed with backfilling operations until Manager's Representative has inspected and approved installations.

3. Areas to be backfilled to be free from debris, snow, ice and water.

4. Do not use backfill material which is frozen or contains ice, snow or debris.

5. Place backfill material in uniform layer thicknesses not exceeding 150 mm for Zones 1 and 6, and 600 mm for Zone. Place concrete sand material in uniform layer thicknesses not exceeding 100 mm and compact using light vibratory compactors. Compact each layer before placing succeeding layer.

6. Do not backfill around or over cast-in-place concrete within 7 days after placing of concrete.

7. Place layers simultaneously on both sides of installed work to equalize loading.

3.8 Restoration

1. Upon completion of work, remove waste materials and debris, trim slopes, and correct defects as directed by Manager's Representative.

4.0 QUALITY CONTROL

As per QA/QC Plan document.

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1.0 GENERAL

1.1 Reference Standards

1. American Society for Testing and Materials.

    a) ASTM F405 - Corrugated Polyethylene Tubing and Fittings

    b) ASTM F667 - Large Diameter Corrugated Polyethylene Tubing and Fittings

    c) ASTM D1248 - Specification for Polyethylene Plastics Molding and Extrusion Materials.

2. Canadian Standards Association.

    a) CAN/CSA B 182.6 - Profile Polyethylene Sewer Pipe and Fittings.

1.2 Submittals

1. Submit product data.
2. Submit installation sequence.
3. Submit installation procedure.

2.0 PRODUCTS

2.1 Plastic Pipe

1. 6" dia. corrugated exterior and interior polyethylene sewer pipe and fittings: [to CAN/CSA B182.6].

    a) Concentric outside ribs to provide rigidity. Pipe to have a complete line of compatible injection molded and fabricated fittings.

    b) Pipe to be manufactured from high density polyethylene resin meeting the requirements of Type III, Category 5, Grade B33 or P34 Class C ASTM D1248.

    c) Gasketed bell and spigot configuration.

    d) Manufactured in 4 m minimum lengths which can easily be trimmed to length during assembly at Site.

    e) 6" dia. perforated pipes provide a minimum of 70 cm^2 perforated area per meter of pipe. The maximum width of a perforation slot shall be 4 mm.

    f) Non-perforated pipes of equivalent or greater diameter are required for the connection between drainage trenches and the inlets out the pump station.

    g) Pipe without perforations to be used for 10 m or either side of the pump station or as directed.

2.2 Filter Material

1. The surrounding granular material shall meet the requirements of Zone 6 as indicated in Specification VM00467-14300-41ES-0006.

3.0 EXECUTION

3.1 Unloading and Handling Pipe

1. Unload by hand or by lifting apparatus with fabric slings, do not use cables or chains.

2. Once removed, lay pipes flat on smooth surface or on sleepers to provide broad bearing surface.

3. Lift, do not drag pipe when moving.

3.2 Trenching

1. Perform trenching work in accordance with Specification VM00467-14300-41ES-0009.

2. Trench alignment to be established on site to minimize excavation depth and provide continuous sloping profile. Commencement of trenching to be approved by Manager's Representative.

3. Use drainage/dewatering measures as per requirements of Specification VM00467-14300-41ES-0009.

4. Place filter material after approval of excavation by Manager's Representative.

3.3 Bedding

1. Place 150 mm layer of Zone 6 over full width of adequately dewatered trench and compact with a minimum of 4 passes of a vibrating plate compactor.

2. Contaminated bedding material to be removed and replaced.

3.4 Installation of Pipe

1. Lay pipe on prepared bed, true to lines and grades with invert smooth and free of sags or high points. Ensure barrel of each pipe is in contact with bed throughout full length.

2. Lay perforated pipes with perforations at 120° and 240° positions from crown of the pipe.

3. Lay bell and spigot pipe with bell ends facing upstream.

4. Fill excavation below bottom of specified bedding adjacent to pumping station with compacted Zone 1B fill. Any contaminated material is to be removed.

5. Surround and cover drain with Zone 6 material in uniform 150 mm layers to an elevation at least 150 mm above top of drain and compact with a minimum of 4 passes of a vibrating plate compactor over each layer.

6. Backfill remainder of trench to requirements of Specification VM00467-14300-41ES-0009.

7. Do not place frozen material in bedding, surround, and backfill. Prevent freezing before completion of trench backfill.

8. Handle, lay, and join pipe in accordance with manufacturer's recommendations. In general, place pipe from high to low points in trench profile.

9. Use adequate measures to prevent water and foreign material from entering pipes during construction.

10. Whenever work is suspended, install removable watertight bulkhead at upstream end of last pipe laid to prevent entry of foreign materials.

11. Lay non-perforated pipes through backfill around pump station.

12. Place non-perforated pipe adjacent to pumping station.

13. Make water tight connections to pumping station.

4.0 QUALITY CONTROL

As per QA/QC Plan document.

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1.0 GENERAL

1.1 Scope

1. This section covers the materials and workmanship, equipment and methods to be used for the supply, placing, curing and finishing of Cast-in-place concrete including supply and installation of form work and reinforcing steel

1.2 Reference Standards

1. The following standards apply except where specified otherwise.

    - CAN3-A23.3-M - Design of Concrete Structures.
    - CAN/C SA-A23.1 -M - Concrete Materials and Methods of Concrete Construction.
    - CAN/CSA-A23.2-M - Methods of Test for Concrete.
    - CAN/CSA-A5 - Portland Cement.
    - CAN/CSA-A23.5 - Supplementary Cementing Materials.
    - CAN/CSA-G30. 18 - Billet- Steel Bars for Concrete Reinforcement.
    - CSA W186 - Welding of Reinforcing Bars in Reinforced concrete Construction.
    - ASTM C494 – Standard Specification for Chemical Admixtures for Concrete.
    - ASTM C260 – Standard Specification for Air Entertaining Admixtures for Concrete.
    - CAN/CSA – S269.3 – Concrete Formwork.

2. American Concrete Institute (ACI) Detailing Manual - SP-66.

3. Concrete Reinforcing Steel Institute – (CRSI).

4. Reinforcing Steel Institute of Ontario (RSIO), Manual of Standard Practice Metric Supplement.

1.3 Submittals

1. Submit the following:

    a) The mill from which the cement is to be supplied and mill test reports covering physical and chemical testing by the manufacturer.

    b) Manufacturer’s technical specifications of proposed admixtures.

c) All characteristics required by CSA-A23.1 for fine and coarse aggregates. Test results shall not be older than 90 days and shall include those specified in Appendix B of CSA-A23. 1 for aggregate reactivity.

d) Determine proportions of concrete materials so as to obtain the required physical characteristics as outlined in the Concrete Mix Schedule, and submit details of trial mixes for review.

e) Detailed descriptions of the proposed placing equipment and methods.

f) Copies of mill test reports and certificates of reinforcing steel.

g) Concrete delivery ticket at the time the concrete is delivered.

h) Quality Control plan for concrete placement and testing.

i) Bar bending schedules including placing drawings for reinforcing steel and welded steel wire fabric as well as support and placing details.

Bar bending schedules including placing drawings for reinforcing steel and welded steel wire fabric as well as support and placing details.

2.0 PRODUCTS

2.1 Concrete Materials

1. The concrete materials to conform to the following standards:

    - Portland Cement: to CAN/CSA-A5. Type 10 unless specified otherwise.
    - Aggregates: to CAN/CSA-A23.1-M. Unless authorized in writing by the Manager's Representative, do not use aggregates deemed reactive when tested for Alkali-Aggregate Reactivity in accordance with CAN/CSA A23.1M.
    - Water: to CAN/CSA-A23.1-M.
    - Supplementary Cementing Materials: to CAN/CSA-A23.5. Obtain the written authorization of the Manager's Representative prior to use of admixtures. Use the same admixture throughout the work. Do not use any admixtures containing calcium chlorides.

2.2 Concrete Accessories

1. Liquid Membrane Forming Curing Compound: CAN/CSA-A23.1.
2. Grout: non-shrink pre-mixed type with a minimum of 20 MPa compressive strength at 24 hours and 40 MPa at 28 days.

2.3 Reinforcing Steel and accessories

1. Reinforcing Steel Bars: to CAN/CSA-G30. 1 8-M, grade 400 deformed billet steel bars.
2. Steel Wire Fabric: to CSA-G30.3-M, Cold-drawn Steel Wire for Concrete Reinforcement, and SAG30.5-M, Welded Steel Wire Fabric for Concrete Reinforcement.
3. Chairs, Bolsters, Bar Supports, Spacers: adequate for strength and support of reinforcing. Non-corrosive and non-staining where specified.

2.4 Formwork Materials

1. Formwork: to CAN/CSA-A23.1.
2. Form Ties: non-corrosive and non-staining at surfaces where concrete will be exposed.
3. Form Oil: non-staining and non-volatile type.

2.5 Design Mix

1. Supply concrete mix proportioned to produce concrete specified in Concrete Mix Schedule.

2. Requirements not specified in the Concrete Mix Schedule shall conform to CAN/CSA-A23.1.

3. Use of admixtures, other than air-entraining admixtures, are not permitted without prior approval of Manager's Representative.

3.0 EXECUTION

3.1 Fabrication and Placing of Reinforcing Steel

1. Fabricate hooks, bends, laps and similar details to ACI Detailing Manual SP-66, and Metric Supplement of the Reinforcing Steel Institute of Ontario (R.S.I.O.) Manual of Standard Practice.

2. Identify each bar with the same code used in the bar bending schedule and placing drawings.

3. Place reinforcing steel in accordance with the tolerances requirements of CAN/CSA-A23.1-M except as shown on the drawings.

4. Provide minimum concrete cover to reinforcing steel in accordance with CAN/C SA-A23.1 -M except where indicated otherwise on drawings.

5. Provide non- corrosive and non- staining reinforcing steel supports

6. Reinforcing steel shall not be re-bent or straightened after initial fabrication unless so indicated on drawings and approved by the Manager's Representative.

7. Do not weld reinforcing steel unless authorized by the Manager's Representative.

3.2 Placing concrete

1. Ensure source, methods of mixing, delivery and placing of concrete are in accordance with CAN/CSAA23.1-M.

2. Prepare existing concrete surfaces on which fresh concrete shall be placed in accordance with CSAA23. 1 clause 19.5. Mix and brush on bonding agent in accordance with manufacturer's instructions.

3. Correct improperly positioned reinforcing prior to placing concrete.

4. Obtain Manager's Representative written approval before placement of concrete commences to ensure that all aspects of cast-in-place concrete are verified.

5. Use winter concreting methods to control and protect concrete in accordance with CAN/CSA-A23.1 when the mean daily temperature falls below 5°C and obtain Manager's Representative written approval before execution.

6. Do not disturb formwork. Compact concrete thoroughly using appropriate vibrators designed for use on each particular application. Avoid contact of vibrators with formwork and reinforcing steel.

7. Perform additional sampling and testing of concrete if, in the opinion of the Manager's Representative, test results or other field observations indicate changes in the quality of the concrete being supplied.

3.3 Finishing Formed Surfaces

1. Rough Finish concrete Surfaces not Exposed to View: place concrete against forms reasonably true and plane. Cut off form ties a minimum of 10 mm below concrete surface. Patch tie holes and defects. Remove fins exceeding 5 mm.

2. Smooth Finish Surfaces Exposed to View: place concrete against plywood, steel or tempered hardboard. Patch tie holes and defects. Remove fins.

3.4 Finishing Unformed Surfaces

1. Scratch Finish Surfaces: consolidate and strike off concrete to true plane not exceeding 5mm in 5 meters and roughen with broom before initial set.

3.5 Curing

1. Keep concrete surfaces continuously damp for a period of seven (7) days during which time the surfaces of the concrete shall be protected from direct sun rays, winds and freezing temperatures.

2. Protect freshly placed and consolidated concrete against damage and from adverse weather conditions.

3. Acceptable Curing Methods:

    a) Ponding or continuous sprinkling.

    b) Absorptive mat or fabric kept continuously wet.

    c) Damp sand, earth, or similar moist material.

    d) Continuous steam vapor mist bath not exceeding 66°C.

4. Curing compounds can be used if approved specifically by Manager's Representative.

3.6 Grout

1. Mix to flowable consistency and place in accordance with manufacturer's instructions.

3.7 Concrete Mix Schedule

Components	Min. Comp. Strength @ 28 days (MPa)	Max Water/Cement Ratio	Max Nominal Agg. Size (mm)	Slump Range (mm)	Air Content Range (%)	Cement Types
Concrete	30	0.45-0.50	20	20-100*	5-8	10

* Final slump will depend on type and thickness of element to be poured.

4.0 QUALITY CONTROL

As per QA/QC Plan document.

-END OF SPECIFICATION

AMEC EARTH & ENVIRONMENTAL	Technical Specification **PLASTIC CONCRETE CUTOFF WALL**	Revision	
		No.	Date
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1.0 GENERAL

1.1 Reference Standards

1.1.1 American Petroleum Institute

- API Specification 13A, Specification for Drilling-Fluid Materials.
- API Recommended Practice 1 3B- 1, Recommended Practice Standard Procedure for Field Testing Water Based Drilling Fluids; 1997.

1.1.2 American Society for Testing and Materials

- ASTM C3 1, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
- ASTM C143 Revision A, Standard Test Method for Slump of Hydraulic Cement Concrete.
- ASTM C403, Time Setting of Concrete Mixtures by Penetration Resistance.
- ASTM D2166, Standard Test Method for Unconfined Compressive Strength of Cohesive Soil.
- ASTM D2850, Test Method for Unconsolidated, Undrained Strength of Cohesive Soils in Triaxial Compression.
- ASTM D4381, Standard Test Method for Sand Content by Volume of Bentonitic Slurries.
- ASTM D4647, Standard Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test.
- ASTM D5084, Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

1.1.3 Canadian Standards Association

- CAN/CSA-A23.1, Concrete Materials and Methods of Concrete Construction.
- CAN/CSA-A23.2, Methods of Test for Concrete.

1.2 Environmental Protection

1. Comply with the requirements of Specification VM00467-14300-41ES-0002 (Environmental Protection) and of the Water License.

1.3 Submittals

1. Submit, at least six weeks prior to start of mobilization from manufacturer, a cutoff wall construction and testing plan including the following:

    - Proposed construction methodology including:
        - details of slurry panel excavation methods, construction sequence with multiple excavators and construction methodology for joints between panels;
        - details of slurry density proposed during both excavation and concreting phases;
        - methods of maintaining and measuring panel verticality;
        - methods of panel cleaning prior to placing plastic concrete;
        - methods of batching and placing plastic concrete.
        - methods of dealing with boulders in till.

    - List of all equipment to be used for panel excavation, slurry preparation and desanding, and panel concreting. Include the number of units, model, year, and type of equipment together with the rated capacity of each. Identify the batch plant proposed to produce the volume of plastic concrete required for the work.

    - Detailed contingency plan outlining steps to be followed in the event of slurry loss, spillage in the lake and trench collapse. (This plan constitutes a construction emergency action plan). Describe the corrective measures to be taken in the occurrence of such events.

    - Detailed procedures for correcting panel deficiencies.

    - Quality control plan.

1.3.1 Submit prior to commencing work:

- Shop drawing of the guidewall design.

- Shop drawing of the Contractor's panel layout and numbering.

- Details of bentonite/water slurry mix including type of bentonite, viscosity, density, pH, filtrate loss, cake thickness, mix proportions and additives.

1.4 Definitions

1. **Plastic concrete cutoff:** A plastic concrete cutoff is a cutoff excavated through the dike fill and overburden to the top of the bedrock or to a prescribed minimum penetration in till, by the slurry panel method of excavation, and backfilled with plastic concrete to form a seepage barrier.

2. **Plastic concrete:** Plastic concrete is a mixture of cement, bentonite, water and fine and coarse aggregates.

3. **Backfill: Backfill** is defined for this work as a plastic concrete mixture used as the final cutoff material.

4. **Slurry panel method of excavation:** The slurry panel method of excavation consists of excavating a panel through soil while at the same time keeping the panel filled with bentonite-water slurry. The basic purpose of the slurry is to maintain the stability of the walls of the panel. Cutoff construction techniques utilizing methods and equipment for mixing soils with cement and bentonite in place in the dike and overburden will not be allowed. Generally primary panels are excavated in three bites referred to as A, B and C bites (B bite being in the center) while secondary panels are excavated in one single bite.

5. **Slurry:** Slurry is a stable, colloidal, thixotropic suspension of powdered bentonite in water.

6. **Bentonite:** Bentonite is a natural clay, of which the principal mineral constituent is sodium montmorillonite.

7. **Surface water:** Surface water is all water that enters the work area above the ground surface from either natural or artificial sources.

8. **Groundwater:** Groundwater denotes all water below the existing ground surface, within the work area.

9. **Construction platform:** The construction platform at elevation 419 m is the surface on which the equipment shall operate to construct the cutoff. The elevation of this surface along the alignment of the cutoff shall be such that it does not cause slurry in any part of the open panels to be more than 0.5 m below the top of the guide walls and no less than 3.0 m above the static groundwater level at the time of cutoff construction.

1.5 Plastic Concrete Laboratory Trial Mix Program

1. Experience from the A154 and A418 dikes construction has indicated that the mix identified as PC8, as outlined below, meets the requirements outlined in Section 1.7 of this specification. The mix proportions are indicated below. The figures in brackets correspond to the weights actually used during the construction of the A154 dike (and verified during construction of the A418 dike) to produce approximately one cubic meter of plastic concrete:

Cement	=	159 kg/m3 (158 kg)
Bentonite	=	40 kg/m3 (40 kg)
Water	=	409 kg/m3 (406 kg)
Fine aggregate	=	677 kg/m3 (672 kg)
Coarse aggregate	=	677 kg/m3 (672 kg)

2. The mix design may require adjustment to suit actual materials and methods used. The mix design shall be adjusted to daily variations in the moisture content of the aggregates in the stockpiles.

1.6 Plastic Concrete Design Requirements

1. Unconfined Compression Strength Test ASTM D2166 (at 23 °C)

• Strength at 28 days	minimum	0.9 MPa
	maximum	1.5 MPa
• Strength at 7 days	minimum	0.6 Mpa

2. Unconsolidated Undrained Triaxial Compression Test ASTM D2850 (150 kPa Confining Pressure, samples cured at 2 °C)

• Strength at 28 days	minimum	1.2 MPa
	maximum	1.8 MPa
• Initial Tangent Modulus - 28 days	maximum	150 MPa

3. Hydraulic Conductivity Test ASTM D5084

- Hydraulic conductivity at 28 days (gradient of 10) less than 1×10^{-6} cm/sec

4. Slump Test ASTM C143

minimum	180 mm
maximum	220 mm

5. Cracked Specimen Erosion Test ASTM D4647 ND (Non-dispersive)

1.7 Environmental Protection

1. Use equipment and construction methods to prevent loss or spillage of bentonite-water slurry into the lake.

2. Line slurry containment ponds with factory seamed HDPE liner, minimum thickness 1.5 mm or acceptable equivalent. If a recirculated slurry pond requires periodic cleaning for removal of the accumulated sludge, protect the pond floor with a concrete slab to prevent damage to the HPDE liner.

3. Grade working surfaces towards trench to prevent spills and contaminated run off flowing into the lake.

4. Promptly remove excavated materials and waste slurry from the construction platform. Stockpiling of excavated materials on the platform is not permitted.

1.8 Qualifications

1. Field personnel: Provide an experienced (10 years minimum) full time, on-site project manager and superintendent, slurry wall and concrete specialists, quality control engineer and support personnel specifically experienced with plastic concrete and plastic concrete seepage cutoffs. Provide one full time supervisor per excavation rig per shift and one full time specialist per shift for concreting (including batch plant quality control). Submit resumes of the proposed superintendent, specialists, and field quality control engineer.

2. Design personnel: Identify design engineering support personnel to be assigned to confirm any modifications of the design of the cutoffs and prepare submittals. Submit resumes of design personnel highlighting relevant experience with deep (approximately 30 m) seepage cutoffs.

3. Manager's Representative review of qualifications: Manager's Representative will review the qualifications of the proposed personnel for approval or rejection. This review may include interviews with the personnel by Manager's Representative.

2.0 PRODUCTS

2.1 Materials

1. Bentonite: - Black Hills Bond Bentonite (sodium montmorillonite bentonite) for plastic concrete and slurry.

2. The use of non-treated bentonite for both slurry and plastic concrete is specified to simplify supply and storage. The use of polymerized bentonite in slurry for panel stability may be proposed by the Contractor subject to approval by Manager's Representative (Black Hills HYG 200 was used for the construction of the A154 dike).

3. Water: Potable, clean and free from deleterious amounts of soil, salts, and organic matter such that the resulting slurry has the necessary properties to provide stability of the panel walls and the plastic concrete mixture has the desired backfill characteristics, meeting the following requirements. Identify source of water and if other than directly from Lac de Gras, submit water quality test results for approval.

Test	Specified Values
pH	About 7.0
Hardness	70 ppm or less
Organic Content	50 ppm or less
Total dissolved solids	500 ppm or less

Water shall be free of oil.

2.1.1 Cement:

- Type 10 Portland Cement, in accordance with CAN/CSA-A5 from Inland Cement Ltd. Where faster setting time is required, use of type 30 Portland cement may be permitted with approval by Manager' Representative.

- All cement to be obtained from the same manufacturing source.

1. Additives to slurry: Additives such as dispersants, plugging agents, viscosity enhancers and/or softeners may be added to the water or slurry, to obtain proper workability of the slurry and efficient use of the bentonite. Submit details of slurry additives to the Manager's Representative for approval.

2.1.2 Aggregates

- Well graded fine aggregate in accordance with Canadian Standards CAN/CSA-A23. 1.

Sieve Size (mm)	Total Passing Sieve, Percentage by Mass
10	100
5	95-100
2.5	80-100
1.25	50-90
0.63	25-65
0.315	10-35
0.16	2-10
0.08	0-5

Well graded coarse aggregate in accordance with CAN/CSA-A23.1.Group 1 10-2.5mm.

Sieve Size (mm)	Total Passing Sieve, Percentage by Mass
14	100
10	85-100
5	10-30
2.5	0-10
1.25	0-5

2.2 Storage

1. Store bagged cement and bentonite in original unopened containers protected at all times from moisture.

2. If bulk storage is used, provide protection at all times from moisture.

3. Provide heat to ensure that water is at a minimum of 4°C at time of mixing.

2.3 Testing Equipment

1. As a minimum, provide and maintain at site the following equipment:

    - 1 Marsh Funnel Set
    - 1 Direct Indicating Viscometer (hand crank or electric)

- 1 Standard Filter Press for low temperature test (carbon dioxide cartridge pressurization system)
- 1 Mud Balance (direct reading of density and specific gravity)
- 1 Sand Content Set
- 1 Slurry Sampler for sampling slurry to depths of 40 m

Graduated probes, weighted tapes and other devices to measure depths of excavation, backfill and to characterize the material at the bottom of the trench.

2. Provide at least two sets of equipment listed above.

3.0 EXECUTION

3.1 Equipment

1. Employ state of the art equipment to excavate with precise orientation to depths of 45 m through dike rockfill and dense to very dense foundation till that is present in both unfrozen and frozen state and that is comprised from silt to boulders.

2. All panel excavation equipment to be provided with built-in inclinometers or other approved devices, and recording equipment.

3. Use of trench cutter equipped with carbide roller bits is mandatory to construct joints between panels satisfying the specified requirements and to excavate into frozen till on land and at abutments and to deal with boulders as and when necessary.

3.2 General

1. Construct plastic concrete cutoff through dike rockfill and till foundation to form a continuous seepage barrier in order that the future mine pit areas may be maintained in a dewatered state.

2. Minimize time all trench panels are open, especially in frozen ground. Backfill with plastic concrete immediately after excavation is complete to minimize thawing of frozen ground and risk of trench collapse in unfrozen ground.

3.3 Plastic Concrete Cut Off Requirements

1. Depth: Generally from El. 417.5 to bedrock or to minimum penetration in till for offshore area and from El. 417.5 into frozen till (or to bedrock) as shown on the Drawings. The minimum penetration is defined as 25 % of the water head or 3 m minimum as illustrated on the Drawings.

2. Thickness: 0.80 m minimum.

3. Length: As shown on the drawings and as modified by Manager's Representative based on foundation conditions.

4. Primary Panel Length: Nominal minimum 3.2 m. Nominal maximum 8.4 m.

5. Secondary Panel Length: Nominal minimum 3.2 m.

6. Alignment: As shown on the drawings.

3.4 Exploratory Holes

1. Manager's Representative may request exploratory holes where required to complement existing information to be drilled before construction of cutoff to define the rock profile.

3.5 Bentonite-Water Slurry

1. Prepare bentonite-water slurry by mixing with high shear colloidal mixer that achieves complete dispersion of the bentonite particles.

2. Completely hydrate bentonite slurry before use.

3. Provide slurry plant consisting of bentonite storage, high shear colloidal mixer, fresh slurry tank or pond, desanding plant, recirculated slurry tank or pond and slurry waste tank or pond.

4. Provide storage capacity for at least two panel volumes of bentonite-water slurry.

5. Prepare bentonite slurry meeting the criteria submitted by Contractor and approved by the Manager's Representative.

6. Maintain the panel excavations in a stable condition. If necessary, use additives and/or weighting agents to increase the slurry density without degradation of slurry filtrate properties.

7. By recirculation to desanders reduce the density of the slurry present in the excavated panel to ensure full replacement of the slurry by plastic concrete while maintaining panel wall stability throughout concreting operation.

8. Where panels are excavated in permafrost, use all reasonable means to maintain slurry temperatures below 5°C (cold lake water for mixing, working at beginning or end of season, short slurry lines etc.).

3.6 Guide Walls

1. Construct guide walls of minimum 1.5 m height.

2. Design guide walls to provide guidance for excavation and to maintain panel verticality.

3. Design guide walls to provide support for construction equipment, to contain the slurry and to resist soil loads.

4. Remove guide walls over a minimum length of 20 m to allow placement of piping at the locations of thermosyphon groups. Alternatively dismantle the upper half of the guide walls and backfill the space between the walls using Zone 1B fill.

5. Elsewhere, guide walls may be left in place or removed after minimum 7 day curing of the plastic concrete provided the cutoff is not damaged.

3.7 Panel Excavation

1. Provide equipment with adequate spare parts, qualified supervision and perform maintenance to minimize downtime.

2. Excavate panels along rectilinear segments approaching as close as possible the cutoff axis shown on drawings.

3. Install permanent steel pins at top of guide walls to mark the limits of each panel.

4. Identify each panel by a sequential number using a steel plate fixed to the slurry pipeline or using other approved means.

5. Using data from exploratory and/or grout holes, previously excavated panels, and observations and probing during excavation, plot anticipated and actual rock profiles and rock conditions for each panel. Prior to completion of excavation for each panel, review these profiles with Manager's Representative and reach agreement regarding final depth of excavation.

6. Do not excavate panels within 50 m of the advancing vibrodensification limits.

3.8 Panel Stability

1. Supply a stable suspension of slurry in the panel excavation and maintain the slurry level as close as possible to maximum level to ensure stability of the panel walls at all times.

2. Take all measures to control slurry loss from the panels in accordance with slurry loss contingency procedures as submitted and approved. Slurry loss control measures may include increasing slurry viscosity, backfilling trench with stockpiled Zone 1B material or backfilling with a cement-bentonite slurry.

3. Adjust panel length to maintain stability.

4. Maintain stockpile of Zone 1B material within 200 m of panel being constructed for emergency backfilling of trench in the event of rapid slurry loss or caving of trench. Provide volume of Zone 1B in stockpile at least equal to the volume of two panels.

3.9 Panel Depth

1. Make every reasonable effort to excavate panels to bedrock including use of weighting agents to produce heavier slurries and thus minimize overbreak. In case of unacceptable overbreak as agreed with Manager's Representative, excavate to a depth of 0.25 H or minimum 3 m into the foundation till, excluding the thickness of any granular material which may be found to overly the till.

3.10 Verticality

1. Maintain panel verticality within 0.5 percent of the depth of the panel.

2. Calibrate inclinometers in panel excavating equipment at start of work and verify regularly.

3. Measure panel deviation using inclinometers in equipment or other approved methods. Perform measurements for both A and C bites in each primary panel and for each secondary panel in two orthogonal axes perpendicular and parallel to cutoff axis. The preferred convention for deviation is positive toward both pit side and increasing stations.

4. With surveyed location of top of panel and readings from inclinometers, plot panel position relative to adjacent panels over full depth.

5. Correct deviations from specified tolerance by special excavation tools, re-excavation or replacement.

3.11 Panel Joints

1. Form joints between primary and secondary panels by excavation into the primary panel a nominal 200 mm so as to ensure at least 50 mm of overlap over the entire height of the panels.

2. Construct panels to provide a minimum transverse overlap of 600 mm over the entire height of the panel.

3. Check joint profile before concreting secondary panel with plots of inclinometer and survey data.

4. In the event of a conflict between the verticality tolerance and the transverse overlap, the transverse overlap requirement governs.

5. Excavate and reconstruct joints not meeting these requirements.

3.12 Horizontal Alignment

1. Construct slurry trench to the centerline alignment shown on the drawings or to other geometry approved by the Manager's Representative with a tolerance of plus or minus 100 mm.

3.13 Panel Cleaning

1. Clean the bottom of panel using a hydro-fraise cutter, by reverse circulation pump or appropriately sized air lift, immediately before placement of plastic concrete.

2. Remove all soil, debris, cobbles, and contaminated slurry pockets.

3. Check bottom condition of panel to verify cleaning.

4. Do not place concrete in panel until Manager's Representative has accepted cleaning in writing (signoff form).

3.14 Desanding

1. Prior to concreting, reduce sand content of slurry to a maximum of 5 percent tested in accordance with ASTM D4381. According to the slurry characteristics, the definition of sand may be modified, with the approval of the Manager' Representative, to include only particles greater than 0.615 or 0.420 mm. To achieve this requirement, circulate fresh slurry into the top of the panel as the excavation slurry is pumped out of the bottom of the panel.

3.15 Concrete Batching

- Provide a plastic concrete batch plant on site for production of plastic concrete for the cutoff wall, with sufficient capacity to continuously place plastic concrete in each panel.
- Mix bentonite and entire volume of water in high shear colloidal mixer and check for adequate hydration.
- Add the hydrated bentonite slurry first followed by cement and aggregates.
- Mix in drum mixer at batch plant before placing in truck for transportation to the site.
- Provide plastic concrete at time of placement at temperature between 15°C and 20°C.
- Provide cold temperature protection for batch plant if required.

3.16 Transportation

1. Transport plastic concrete and place in panel within 60 minutes of batching.
2. Transport plastic concrete by truck with continuous rotary agitation until placement.

3.17 Plastic Concrete Placement

1. Place plastic concrete in panel by tremie method such that the concrete displaces the slurry from the bottom. Do not allow slurry to mix with concrete.
2. Place plastic concrete through a hopper and rapid connect leakproof tremie pipe minimum 200 mm diameter, to permit free flow of concrete.
3. Place concrete in panel as rapidly as possible without interruption.
4. Maintain a positive concrete head throughout placement.
5. Keep the bottom of the tremie pipe embedded in the placed concrete a minimum of 1.5 m.
6. Provide at least one tremie pipe for each 3.2 m panel and at least two tremie pipes in each 8.4 m panel. Raise all tremie pipes in a panel simultaneously.

7. Do not move tremie pipes horizontally.

8. Generally plastic concrete is to be placed to minimum elevation 418.0 without exceeding elevation 418.5, unless otherwise approved by Manager's Representative, to ensure that uncontaminated plastic concrete has reached at least elevation 417.5.
9. Pump displaced slurry uncontaminated by concrete to holding pond. Dispose of contaminated slurry as directed by Manager's Representative.

10. Horizontal construction joints in the panels are not permitted.

4.0 QUALITY CONTROL

As per QA/QC Plan document.

-END OF SPECIFICATION

AMEC EARTH & ENVIRONMENTAL	Technical Specification **JET GROUTING**	Revision	
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☐ Entire specification revised. Reissue all pages.

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1.0 GENERAL

1.1 Reference Standards

1.1.1 American Petroleum Institute

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- API Recommended Practice 13B- 1, Recommended Practice Standard Procedure for Field Testing Water Based Drilling Fluids; 1997.

1.1.2 American Society for Testing and Materials

- ASTM C3 1, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
- ASTM D2850, Test Method for Unconsolidated, Undrained Strength of Cohesive Soils in Triaxial Compression.
- ASTM D4647, Standard Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test.
- ASTM D5084, Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

1.1.3 Canadian Standards Association

- CAN/CSA-A23.1, Concrete Materials and Methods of Concrete Construction.
- CAN/CSA-A23.2, Methods of Test for Concrete.

1.2 Environmental Protection

1. Comply with the requirements of Specification VM00467-14300-41ES-0002 (Environmental Protection) and of the Water License

1.3 Submittals

1. Submit at least one week prior to start-up, jet grouting construction plan including the following:
   - Proposed construction methodology:
     - Description of basic jet grouting system proposed (double or triple fluid systems).
     - Details of maintaining and measuring borehole orientation. Provide references of

previous work where proposed directional survey equipment has been used successfully.

- Details of air, water, and grout pressure and flow rate, withdrawal rate and rotation speed of the drill rods.

- List of equipment to be used. Provide information of the:
  - Drill rods and drill bits.
  - Grout injection monitors with nozzles.
  - Grout pumps.
  - Air compressor system.
  - Details of batching plant, grout holding tanks and transfer system.
  - Details of automatic injection control system and data recording equipment.
- Details of disposal of waste material resulting from all jet grouting operations.
- Detailed procedures for correcting hole alignment deficiencies.
- Outline steps to be followed if, due to ground conditions, no grout return to surface is obtained.
- Details of the quality control program.
- Proposed trial mix design and testing program for jet grouting including:
  - Material sources
  - Material testing
  - Description of proposed trial mixes and trial field testing program

2. During the course of construction submit the following:
   - Copies of quality control test results.
   - Description of basic jet grouting system proposed (double or triple fluid systems).
   - Details of maintaining and measuring borehole orientation. Provide references of previous work where proposed directional survey equipment has been used successfully.

  - Details of air, water, and grout pressure and flow rate, withdrawal rate and rotation speed of the drill rods.

- List of equipment to be used. Provide information of the:
  - Drill rods and drill bits.
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- Details of the quality control program.
- Proposed trial mix design and testing program for jet grouting including:
  - Material sources
  - Material testing
  - Description of proposed trial mixes and trial field testing program

3. During the course of construction submit the following:
   - Copies of quality control test results.
   - Certification from suppliers that the bentonite and cement meet the requirements of the specification for each batch delivered to site.
   - Records of drilling, orientation measurements and grouting.
   - As built drawings.

1.4 Definitions

1. **Jet grouted cutoff:** The jet grout cutoff for the A21 dike extends from the bottom of the previously constructed plastic concrete diaphragm wall through the glacial till, fluvio-glacial and glaciolacustrine deposits and penetrates a minimum of 1.5 m into the bedrock. The work may also require columns to be constructed in Zone 1B fill and/or in overburden where the diaphragm wall has not been constructed.

2. **Jet grouting:** The technique consists of drilling holes by rotary or roto-percussion method with low pressure water jet until the required depth in rock is reached.

   Subsequently, a high velocity horizontal jet is used to cut and remove the fine portion of the till and of the infilling joint materials in the bedrock, leaving in place the coarser portion of the soil which is incorporated into the cement bentonite slurry to form a soilcrete column having the specific geotechnical requirements stated below.

   A conical air jet shroud conserves the energy of the grout jet in the double fluid system while in the triple fluid system, a water cutting jet is surrounded by air and a separate grout jet situated below the water jet is provided for creating columns during the rod withdrawal.

   The rods for the injection system are usually the same as those used for drilling but may be separate.

3. **Jet Grout Column:** The jet grout process will form a cylindrical column of soilcrete in weathered rock, the till material and the lower 0.5 m of the panel wall. It is not expected that the cutting jet will destroy sound rock. The jetting action will remove joint infilling and permit replacement by grout.

4. **Grout:** Grout is a mixture of cement, bentonite and water.

5. **Bentonite:** Bentonite is a natural clay, of which the principal mineral constituent is sodium montmorillonite.

6. **Construction platform:** The construction platform at elevation 419 m is the surface on which the equipment shall operate to construct the jet- grouting cutoff.

7. **Jet Grouting Design Requirements:** The intention of Section 1.5 is to establish the parameters which provide a continuous impervious jet grouting cutoff while minimizing the consumption of cement. The objectives are to obtain the specified permeability, the stability of the curtain grout drill holes and the specified strengths. If these objectives cannot all be obtained, then the required strength will be adjusted.

8. **Mix Ratios:**

Minimum Cement / Water Ratio	0.6 for double fluid system 0.8 for triple fluid system

Minimum Bentonite / Water Ratio 0.03

Such as to ensure a stable mix (bleed less than 5 % of clear water above settled solids) and so as to ensure the compliance with Sections 1.5.2 to 1.5.5.

9. Unconfined Compression Strength Test CAN/CSA-A23.2 (23°C) for samples representing in-situ mix.

- Strength at 28 days: minimum 0.8 MPa
  maximum 2.0 Mpa

Subject to confirmation or revision after trials.

- Strength at 7 days: minimum 0.5 MPa
- Strain at failure-28 days: minimum 1.0%

Tolerances: 2/10 samples may be less than 0.8Mpa at 28 days but not less than 0.7 MPa and 1/10 samples may be less than 0.8 MPa but not less than 0.6 MPa. 1/10 samples may be less than 0.5MPa at 7 days but not less than 0.4 MPa.

Establish correlations between characteristics of cylinders prepared from fresh slurry and cylinders prepared from slurry sampled in the completed column prior to setting. Carry out routine control testing of the fresh slurry based on these correlations.

10. Hydraulic Conductivity Test ASTM D5084 on samples obtained from columns and cured at 2°C.

Hydraulic conductivity at 28 days: less than $1x10^{-6}$ cm/sec under a gradient of 30, subject to confirmation or revision after trials.

Tolerances: 1/10 samples may exceed $1x\ 10^{-6}$ cm/sec but not to exceed $1x\ 10^{-5}$ cm/sec.

11. Cracked Specimen Erosion Test ASTM D4647 ND (Non-dispersive)

12. Objective: that the jet grout mix will provide columns, cured under field conditions that will permit drilling for the execution of curtain grouting 7 days after jet grouting. Longer periods will only be considered if compatible with overall schedule. Holes should stay open and be stable. Obtaining core is not a prerequisite except during the trials or if specifically requested for certain columns identified by Manager's Representative prior to execution. By means of the trials and the laboratory testing results obtained from the production columns, collaborate with the Manager's Representative to confirm as soon as possible the water:cement ratio which will attain the objectives.

1.5 Environmental Protection

Use equipment and construction methods to avoid loss of cement grout into the lake. Promptly remove return fluid and waste grout from the dike. Stockpiling of waste materials on the dike is not permitted, except in engineered containment facilities approved by Manager's Representative.

1.6 Qualifications

1. Field personnel: Provide an experienced (10 years minimum) full time, on-site project manager. Provide a superintendent, jet grouting specialists, quality control staff and support personnel specifically experienced with jet grout cutoffs. Provide one full time supervisor per rig per shift and one full time specialist per shift for the batch plant. Submit resumes of the proposed superintendent, specialists, and field quality control engineer.

2. Support personnel: Identify engineering support personnel to be assigned to propose any modifications of the design of the cutoff and prepare submittals. Submit resumes of support personnel highlighting relevant experience with deep seepage cutoffs.

3. Manager's Representative review of qualifications: Manager's Representative will review the qualifications of the proposed personnel for approval or rejection. This review may include interviews with the personnel by Manager's Representative.

1.7 Safety

1. Comply with the NWT Mines Act/Regulations pertaining to all compressed air related equipment.

2.0 EQUIPMENT

2.1 Drilling

2. Employ state of the art equipment to produce minimum 75 mm diameter holes with precise orientation through plastic concrete, crushed stone, medium dense to very dense till, including boulders, and rock. Drilling equipment may be part of grout system or separate.

3. Use rotary or roto-percussion drilling technique with water flush. Use drilling tools and methods to prevent damage to the diaphragm wall.

4. The borehole shall be stable and have sufficient annular space between the jet grout drill rods and the sidewalls of the drill hole to be able to maintain a constant flush of cuttings to the surface.

5. Use drilling technique able to achieve a maximum target drilling deviation of 1% or less. The presence of boulders in till will necessitate drilling equipment capable of drilling through these materials. Use equipment capable of drilling and jet grouting to depths up to 35 meters.

6. Equip the jet grout drill with an integrated data acquisition system which during drilling will continuously monitor the following:

    a. Clock Time
    b. Drilling Speed (meters per minute)
    c. Thrust on Drill Rods (kilo -newton)
    d. Torque (kilo -newton – meter)
    e. Drill Rod RPM's (revolutions per minute)
    f. Drilling Fluid Pressure (Mega-Pascal)

7. Drills are to be supplied with downhole sampling tools to recover samples from the jetted columns before soilcrete setting.

2.2 Jet Grouting

1. Use double or triple fluid jet grout system.

2. The water cutting jet is sheathed in an annulus of compressed air.

3. For triple jet systems, a lower cement-bentonite grout jet is positioned in relation to water jet, and the fresh mix is chosen such that the resulting in-situ grout acquires the specified characteristics despite effects of dilution caused by in-situ mixing.

4. Establish rod rotation speed and lift speed according to Contractor's experience.

5. Equip the jetting system with data acquisition units and appropriate instrumentation to continuously acquire the following jet grouting parameters:

- Clock Time
- Water Pressure and Flow Rate
- Air Pressure
- Grout Pressure, Flow Rate, and Density Depth below Ground Surface,
- Drill Rod rpms

2.3 Mixing and Delivery

1. Provide automatic batch plants on site for production of grout for the cutoff wall, with a capacity to permit continuous operation of the jet grouting.

2. Provide compressors and pumps to deliver air, water and grout to the jet grout sites at the required rates and pressures. It is anticipated that the pressures at the nozzles will be at least the following:

Air	7 bars
Water	400 bars
Grout	100 bars

Provide mixing and pumping equipment capable of delivering grout at a rate of 110 to 250 l/min.

2.4 Testing Equipment

1. As a minimum, provide and maintain at site the following equipment:

    - 1 Marsh Funnel Set
    - 1 Mud Balance (direct reading of density and specific gravity)
    - Down hole directional survey equipment for measuring inclination of boreholes equipped with surface read out facilities. The equipment shall be capable of making inclination observations on two orthogonal axes parallel and perpendicular to the cutoff alignment. The probe shall fit into the triple fluid rods and descend the entire length of the holes to the top of the injection monitor.

A sufficient number of sampling tools to obtain samples of grout from the columns before setting.

3.0 PRODUCTS

3.1 Materials

3.1.1 Bentonite

Black Hills Bond (sodium montmorillonite bentonite) or approved equivalent.

3.1.2 Water

- Potable, clean and free from deleterious amounts of soil, salts, and organic matter meeting the following requirements. Identify source of water and if other than directly from Lac de Gras, submit water quality test results for approval.

Test	Specified Values
PH	• About 7.0
Hardness	• 70 ppm or less
Organic Content	• 50 ppm or less
Total dissolved solids	• 500 ppm or less

- Water shall be free from oil.
- Provide heat to ensure that water is at a minimum of 4°C at time of mixing.

3.1.3 Cement:

- Cement to be type 10 or type 30 Portland Cement, in accordance with CAN/CSA-A5 from Inland Cement Ltd.

- Obtain all cement from the same manufacturing source. Storage

3.2 Storage

1. Store bagged cement and bentonite in original unopened containers protected at all times from moisture.

2. If bulk storage is used, provide protection at all times from moisture.

3. Dye

4. Upon request from Manager's Representative, supply environmentally acceptable dye for use in jet grout mix in columns where borehole camera survey is required and planned in advance. Manager's Representative will specify type of dye.

4.0 EXECUTION

4.1 General

1. Construct jet grouted cutoff penetrating a minimum of 1.5 m deep into the bedrock and rising to cut at least 0.3 m into the bottom of the plastic concrete diaphragm panels to complete the continuous seepage barrier of the A418 dike.

2. Continuously record all the drilling parameters listed in paragraph 2.1.5 and provide a plot of parameters versus clock time for each drill hole.

4.2 Jet Grouting Cutoff Requirements

1. **Jet grouting scope:** Drilling a single row of holes and produce columns of an adequate diameter such that the minimum transverse overlap is 800mm.

2. **Depth:** Minimum of 1.5 m into bedrock.

3. **Transverse width:** 0.80 m minimum (at column points of contact). Holes to be vertical.

4. **Inclination:** Holes to be vertical.

5. **Length:** As shown on the drawings and as modified by Manager's Representative based on foundation conditions.

6. **Alignment:** As shown on the drawings.

7. **Spacing between columns:** 0.75 m or as approved by Manager's Representative.

4.3 Test Sections

1. Construct test sections at location defined by Manager's Representative before proceeding with production. Certain test holes will be allowed in parallel with production.

2. Execute trials consisting of 3 or 4 groups of three columns in a triangular configuration to be used to demonstrate column diameter. Set inter-axis spacing of each group at 0.866 times the anticipated diameter or propose alternative method to confirm the achieved diameter. Use grout with C:W ratio of 1.2:1 for these columns to permit early coring. Locate groups

such that two columns of each group form part of the permanent cutoff. Identify groupings as A1, A2 etc.

3. Monitor the following:

    - Equipment performance
    - Deviation of the columns
    - Characteristics of fresh grout, return grout and grout sampled from completed columns.

4. Perform test drilling in the columns and column groups at least seven days after completion of the jet grout columns with c:w ratio of 1.2:1

5. Drill minimum S size coreholes or approved equivalent at the centroid of column groups A in compliance with Specification VM00467-14300-41ES-016 (Drilling). Measure hole deviation. Column diameter will be inferred from the presence or absence of grout in the drill cores.

6. Place core samples in core boxes, label depths of core run, protect from freezing and turn over to the Manager's Representative for laboratory inspection and testing.

7. Perform simple pump out tests in the boreholes to verify water tightness. Measure rate of rise of water level in the borehole to calculate permeability by calculation procedure to be agreed upon with Manager's Representative.

8. Cooperate with Manager's Representative in carrying out borehole camera survey of the holes if required.

4.4 Jet Grouting Depth

1. Penetrate 1.5 m depth into bedrock and treat by jet grout process. Adjust drilling depth to ensure that grout jet reaches 1.5 m depth.

2. Where curtain grouting has preceded jet grouting, ensure that jet grouting overlaps a minimum of 0.5 m with curtain grouting so as to avoid the occurrence of any window. To this end, ensure coordination between the two teams is maintained at all times.

3. If a triple fluid system is used, carry out single fluid jet grouting in rock using grout pressure of at least 100 bars and grout flow of at least 150 l/min(water and air almost shut off) and maintaining the same withdrawal rate until the water/air nozzle reaches the elevation of the bedrock surface.

4. Extend jet grout column to at least 0.3 m but not more than 1.0 m above the highest recorded position of bottom of each panel as obtained from soundings prior to concreting and according to information derived from drilling parameters.

5. Turn off water and air and complete grout injection in lower portion of panel until neat grout appears at collar of holes.

6. Sample grout in column below base of wall in first ten columns and thereafter in every fifth column, as directed by Manager's Representative.

4.5 Directional Control

1. Maintain drill hole orientation within 1 percent of the full depth of the hole. Deviations will be tolerated only if joint overlap (see section 4.6) is maintained.

2. Check orientation using an inclinometer or other approved methods.

3. Check orientation for each borehole.

4. Correct deviations from specified tolerance by re-drilling hole or replacement with additional columns as required.

4.6 Joints

5. Construct columns to provide a minimum transverse width of 800 mm over their entire height at column overlap.

6. In the event of a conflict between the orientation tolerance and the 800 mm minimum width over the entire height of the column, the 800 mm width requirement governs.

7. Redo columns not meeting these requirements or construct additional columns.

8. Additional columns may be required when the Manager's Representative determines from the drilling parameter records that the boulder content is significant. The additional columns will be located on an alignment parallel to and on the upstream side of the dike axis.

9. Maintain jet grout parameters (grout pressure and flow, air pressure, water pressure and flow, withdrawal rate, rotation speed etc) within 10% of values set as a result of the trials unless any deviation from the established jet grout parameters is otherwise accepted by Managers' Representative. In the event of deviations outside these limits, or in the event of temporary failure of automatic recording system, provide adequate information to demonstrate that the column has been correctly constructed. Add additional columns if the said demonstration cannot be made.

4.7 Horizontal Alignment

1. Carry out jet grouting on the centerline alignment of the cutoff wall as actually built with a tolerance of plus or minus 25 mm at the collar as measured between adjacent columns.

2. Prior to commencing jet grouting operations, survey column centers and place adequate markers (e.g. pins and paint) on concrete guide walls to identify column position and I.D. number.

4.8 Grout Mixing

1. Mix bentonite and water and check for adequate hydration as follows. Plot viscosity versus time of mixing in order to determine time of mixing to attain a constant or near constant viscosity.

2. Mix the cement and the hydrated bentonite.

3. Mix in high shear colloidal mixer and continuously agitate in holding tanks.

4. Provide grout at time of injection at a minimum temperatureof 5°C. In permafrost areas temperature is not to exceed 20°C.

5. Provide cold temperature protection for batch unit and delivery lines if required.

4.9 Delivery

1. Insulate and heat delivery lines for cold weather operation as required.

2. Provide communication system and controls to permit rapid pump shut off and line closure to prevent grout spill in case of line breakage or damage.

4.10 Jet Grout Placement

1. Prior to commencing jet grouting operations, prepare a table indicating for each column: station, column number, assumed bedrock level (from exploration data), bedrock level as established from curtain grouting, bedrock elevation interpreted from jet grout drilling records, actual column depth required, etc.

2. Do not drill holes for jet grouting until the plastic concrete cutoff wall has aged for a minimum of 7 days.

3. Should the work schedule require that jet grouting be carried out in a plastic concrete primary panel whose adjacent secondary panel has not been built yet, jetting shall not be carried out at a distance of less than two column diameter from the panel ends.

4. Inject grout with rod rotation speed and withdrawal rates as determined from trials and as acceptable to the Manager's Representative.

5. Maintain the grout delivery and monitor return of grout at hole collar at all times to ensure that after grouting an effective jet grouting cutoff with no voids or unconnected zones is constructed. Use a split spacing construction sequence. Adjust sequence of borehole drilling and grouting so as to maintain a distance of at least one column diameter between the freshly installed columns and panels and any new injection. A minimum time of approximately 24 hours is to elapse before jet grouting next to an existing column.

6. Place mixing plant in a secure location and operate to prevent spillage of material into the lake.

7. Promptly remove debris and water from storage, mixing, transport, placement and clean-up of equipment from the working platform.

8. Ensure that drilling facilities include recovery system for mud or additives to prevent such materials from being discharged into the lake.

9. Top up drill holes with grout after completion of grouting as necessary to compensate for decantation or leakage. Record instances of above average grout requirement.

10. The triple fluid technique uses a water jet which causes grout dilution and bleeding. When drilling in the cutoff wall is carried out adjacent to columns whose grout has not set, install a riser pipe at the collar of such locations to prevent ingress of drill cuttings and fluid and thus ensure that each hole drilled across the cutoff wall has been filled entirely with grout only. Verify the grout level regularly in the freshly grouted columns and top up as necessary.

11. Ensure a signoff form is prepared for each column and approved by the work supervisor, the quality control personnel and the Manager's Representative to testify that each column has been constructed with the required standards of quality.

5.0 FIELD RECORDS

- Prepare and submit daily activity report with work completed, delays, and problems encountered, breakdowns, etc.

- For each rig, prepare a table indicating bedrock elevation from all available sources (including curtain grout hole drilling) and the required column depths to be jetted and submit daily (hard copy and Excel format).

- Keep records of the following for each column and submit daily:

  - I.D. Number, depth and date of hole drilling and injection
  - Drill rod and bit size
  - Type and depth of materials encountered in drilling
  - Drilling and jetting parameter recordings over full depth
  - Drilling deviation survey
  - Other observations (communication, heave or subsidence, etc.)
  - Mix proportions
  - Density of mix
  - Viscosity of mix
  - Volume injected into hole
  - Injecting pressure
  - Rate of rod withdrawal
  - Rotation speed of drill rods
  - Jet grout consumption and loss, description of return
  - Details of corrective measures
  - Signoff form for each column jetted

Records to be furnished within 24 hrs of completion for each and every column in hard copy and electronic format.

Digitized data to be submitted along with a hard copy output . The hard copy of drilling and jetting recordings is to be provided with color coded graphs.. The exact format of the digitized data to be coordinated with the Manager's Representative.

Note: A digital ASCII file of drilling and grouting parameters, suitable for conversion to input into Microsoft Excel Spreadsheet will be acceptable. The files should contain the following data scanned continuously:

a) during drilling: clock time, depth, drilling rate, rotary speed, thrust on tool, rotary torque, drilling fluid pressure.

b) during jet grouting: clock time, depth, water pressure and flow rate, air pressure, grout density/pressure/flow rate, and revolutions per minute (rpm).

- Batching and Mixing Records
  - Document the following:
    - Mix proportion
    - Time of mixing
    - Sample identification numbers.
  - Provide 3 copies of above records for each day, distributed as follows:
    - Copy 1: Contractor
    - Copy 2: Manager's Representative's Inspector
    - Copy 3: Manager's Representative's Central File

- Prepare and submit daily a spreadsheet in Excel format indicating all related data pertinent to columns jetted, including column number, panel number and bottom elevation, station, date of jetting, shift, type of column (primary, secondary, closure, repair, additional), column top and bottom elevation, deviation measurements, mix used, volume of grout jetted, elevation of bedrock, and laboratory test results (hydraulic conductivity, compressive strength and triaxial test results at 7, 14 and 28 days).

- Prepare and submit a table of effective column diameter, inter-axis spacing at surface and at depth (z at 3 meters intervals) for each jet grout column interval and wall thickness at the overlap, at depth intervals of 3 m in order to document the calculated column overlaps.

6.0 VERIFICATION CORE DRILLING

1. Perform vertical or inclined verification boreholes with minimum S size triple tube core barrel equipment in compliance with Specification VM00467-14300-41ES-0016 (Drilling) to obtain samples of plastic concrete, grout and rock to a depth of 2 m minimum into rock. One hole per 50 m of cutoff length is required unless otherwise instructed by the Manager's Representative. Place cores in core boxes, protect from freezing and deliver to Manager's Representative. Laboratory testing on selected core samples (unconfined compression, density) as directed by Manager's Representative.

2. Provide detailed description (using standardized terminology as agreed with Manager' Representative) and colour photographs of cores.

3. Document that all soil-cement retrieved from core runs in jet grout treated area is well mixed cemented soil without any detrimental cavities or untreated soil inclusions. Document presence of curtain grout in rock joints.

4. Cooperate with Manager's Representative in carrying out borehole camera survey of the holes if required.

5. Perform simple pump out tests and rising head measurements to determine permeability as specified by Manager' Representative. Eighty percent (80%) of tests to comply with requirement of 1×10^{-6} cm/s, no test result to exceed 1×10^{-5} cm/s.

7.0 DEFICIENCIES

1. Correct deficiencies in columns such as inadequate top or bottom elevations, occurrences of windows in cutoff due to jet grouting parameters not conforming with approved requirements, lack of grouting records, inadequate column spacing, etc.

2. Proposed correctives measures to Manager's Representative for approval.

3. Correct deficiencies within 15 days of notification of Manager's Representative.

8.0 QUALITY CONTROL

See QA/QC Plan document.

-END OF SPECIFICATION

AMEC EARTH & ENVIRONMENTAL	Technical Specification **CURTAIN GROUTING**	Revision	
		No.	Date
	VM00467-14300-41ES-0014	0	Aug/07

INSTRUCTION TO DOCUMENT CONTROL

☐ Entire specification revised. Reissue all pages.

☐ Reissue revised pages only

STAMP THE SPECIFICATION AS FOLLOWS:

☐ Issued for comments

☐ Issued for tender

☒ Issued for approval

☐ Issued for purchase

☐ Issued for construction

SPECIFICATION REVISION INDEX

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1.0 GENERAL

1.1 Reference Standards

1. Canadian Standards Association

   a) CAN/C SA-A5 - Portland Cement.

   b) CAN/CSA-A23.1 - Concrete materials and Methods of Concrete Construction.

   c) CAN/CSA-A23.2 - Methods of Test for Concrete.

2. American Petroleum Institute

   a) API Specification 13A, Specification for Drilling Fluid Materials.

   b) API Recommended Practice 13B- 1, Recommended Practice Standard Procedure for Field Testing Water-Based Drilling Fluids, 1997.

1.2 Environmental Protection

1. Comply with the requirements of Specification VM00467-14300-41ES-0002 (Environmental Protection) and of the Water License.

1.3 Submittals

1. Submit grouting plan including:

   a) Equipment list including grout mixers, grout pump, hoses, holding tanks, packers and rods or tubing.

   b) Layouts of expected grouting arrangements, including protection for work in cold weather.

   c) Sequence of work and schedule of activities related to the dike construction, Zone 1 and Zone 1B densification and cut off wall construction.

   d) Methods of recording quantities of materials used and grout fluid injected.

   e) Grouting approach and methodology including planned hole size in cutoff wall or Zones 1 and 1B fills, overburden till and rock, packer size and type, and grout tubing size and type.

   f) Supplier and specification for materials used in grout mixes (ex. admixtures).

g) Results of laboratory testing on the proposed grout mixes, including for each grout mix: water-cement-admixture ratios, density, viscosity, bleeding, temperature, initial and final setting time, unconfined compressive strength at 3, 7, 14 and 28 days.

h) Calibration certificates for all measuring devices.

1.4 Definition

2. **Stage:** Specific length of grout hole defined by top and bottom depth, isolated by single/double packer and subjected to water or grout injection.

3. **Section:** Horizontal length of grout curtain defined by station survey data.

4. **Water pressure test:** Injection of water into rock under a certain pressure and for a certain duration using single or double packers, for the purpose of assessing rock permeability.

5. **Rate of grout take:** Rate of injection of cement grout slurry in L/min. in a given stage of a given grout hole.

6. **Refusal:** Point at which grout injection is considered complete in a given stage of a given hole, as defined by this specification and as modified by Manager's Representative.

7. **Water-cement ratio:** Ratio by weight of water to weight of cement.

8. **Gauge pressure:** Pressure measured by pressure gauge at header.

9. **Effective grouting pressure:** Pressure of grout, while being pumped, at the midpoint of the stage of the hole being grouted, as calculated from the gauge pressure at the header plus the pressure head due to the weight of grout in the hole and feed lines minus the pressure head due to the water table.

10. **Split spacing:** The procedure of systematic reduction of the grout hole spacing by drilling and grouting additional holes between those holes which have previously been drilled and grouted.

11. **Grout take:** Measure of grout injection in the rock or particular stage, in kg of cement.

12. **Unit grout take:** Grout take in kg of cement divided by length of particular stage in a particular grout hole.

13. **Additives:** Ingredients added to the grout mix in small amounts to improve mix flow/setting/strength characteristics.

14. **Lugeon:** Measure of rock permeability, Equals 1 liter/min/m of hole at an effective test pressure of 10 bar.

1.5 Qualifications

1. Provide experienced operating and supervisory personnel for each grouting plant in operation.

2.0 PRODUCTS

2.1 General

1. Handle, store and protect all materials from deterioration and contamination. Do not use deteriorated or contaminated materials.

2.2 Grout

1. A mixture of Portland cement, water and superplasticizer designed to suit particular conditions. Sand and/or bentonite and other additives may be added to the grout, if required and acceptable to Manager's Representative. The grout must be stable, i.e. it must have a bleeding ratio of less than 5 % after 2 hours.

2.3 Water

1. Fresh, clean and free from deleterious amounts of oil, silt, organic matter, alkali, acids, salts and other impurities in accordance with CAN/CSA-A23.1. At the time of mixing, the temperature of water used in grout mixes shall be less than 25°C and greater than 5°C.

2. Provide adequate water storage facilities to ensure a continuous supply of water for the grouting operations, and to ensure that grouting operations are not hindered by a temporary breakdown in the main supply line.

2.4 Cement

1. Type 30 Portland Cement, in accordance with CAN/CSA-A5.

2. Do not use cement containing lumps or foreign matter which Manager's Representative considers detrimental to the results of the grouting program. Ensure the temperature of the water is above 5°C when added to the grout mix.

3. Store each shipment of cement so that it is protected from the weather and is readily distinguished from other shipments. Use oldest batches first, but otherwise use in most efficient manner.

2.5 Sand

1. Clean, durable stone particles from natural sand or crushed stone, free from lumps of clay and foreign matter, at a moisture content of less than 3 percent of the dry weight conforming to CAN/CSA-A23.1 with the following modified gradation requirements or equivalent approved by Manager's Representative:

Sieve Size (mm)	Total passing sieve, percentage by mass
2.5	100
1.25	95-100
0.630	65-85
0.3 15	30-50
0.160	10-30
0.080	0-5

2.6 Bentonite

1. Bentonite: Black Hills Bond (sodium montmorillonite bentonite) from Black Hills Bentonite, Mills, Wyoming.

2.7 Additives

1. Use retarding, expanding and fluidifying admixtures for cement and sand-cement grouts obtained from the same manufacturer to ensure that they are compatible with each other.

2. Mix, handle, store and apply admixtures in accordance with manufacturer's recommendations.

3.0 EXECUTION

3.1 Drilling

1. Drill cased grout holes through the cutoff or Zones 1 and 1B fills, overburden and into rock in accordance with specification VM00467-14300-41ES-0016 using casing as necessary to support the hole.

2. Measure deviation in accordance with specification VM00467-14300-41ES-0016.

3. The grout holes shall have an inclination of 75 degrees measured from the horizontal except at abutments where if required hole inclination in the plane of the cutoff may be changed to better match the grout hole pattern with the permafrost boundary. The Manager's Representative may further designate different orientations along portions of the dike alignment to optimize interception of prevailing geologic structure.

3.2 Grouting Equipment

1. Provide grouting equipment including mixers, grout pumps, packers, pipes, grout lines, fittings, valves, nipples, drills, pressure gauges, gauge savers, electronic grout flow meters, telephones or radios, lighting circuits, supplies, tools and spare parts necessary to inject a continuous supply of grout into the rock foundation under accurate pressure control and to closely monitor the operation.

2. Provide equipment that is new or completely overhauled to an «as-new» condition.

3. **Mixers -** High speed colloidal mixer (operating speed 1400 to 2000 rpm). Provide facilities at the mixer for the accurate measurement of grout materials so that mix proportions can be controlled.

4. Maintain grout materials in suspension in a mechanically agitated sump or holding tank, equipped with paddles rotating at adjustable speeds of 40-200 rpm and screens, 6mm maximum opening size, to remove hardened grout. Graduate the sump or tank in liters.

5. **Pumps -** Progressive cavity (Moyno) type capable of pumping at least 110 l/min of grout at a maximum discharge pressure of 2 MPa. Locate pumps at a distance not greater than 100 m from the hole being grouted.

6. Hoses, Connections and Headers:

    a) Provide a circulating system of hoses, of minimum 25 mm internal diameter, from the pump to the header and back to the holding tank.

    b) Provide grouting headers for feeding grout into the hoses located at the top of the grout hole. The grout headers include a supply connection, a connection with a valve to the hole,

a return line with a valve, and two pressure gauges for the appropriate pressure range. One pressure gauge located at the grout pump to indicate the pressure of the supply of grout to the hole. The other to measure the pressure of grout going into the hole.

c) Provide hoses, valves, joints and couplings capable of withstanding pressures double those required for grouting.

7. **Water Meters -** Single-disc type calibrated to measure liters and 1/10 of liter equipped with an accumulative totalizer and a reset knob, or equivalent.

8. **Pressure Gauges -** Bourdon tube type of heavy duty quality 150 mm minimum dial gauge diameter. The gradation of the pump discharge pressure gauge shall be the same as the header gauge and both gauges shall be changed, to suit the range of grouting pressures required by Manager's Representative. Protect gauges installed in the grout lines by a membrane-type straightway gauge saver filled with glycerin, or equal non-freezing fluid. Provide a standard master gauge against which all other gauges shall be checked periodically for accuracy and satisfactory operation.

9. **Communications -** Provide telephone or radio communications between mixing station, pumping station and grout hole location.

10. **Compressed Air Supply -** Supply sufficient compressed air to operate compressed air equipment at full capacity.

3.3 Schedule

11. Perform laboratory tests on trial mixes at least 30 days before starting the work.

12. Perform grouting either before or after construction of cut off wall as approved by Manager's Representative. Allow minimum 14-day delay from completion of cutoff wall in a given area before commencing pressure grouting.

13. Drill grout holes from working platform at El. 419.

14. Do not drill grout holes within 12 m of another grout hole which is being grouted or within the initial setting time of the grout in that hole.

3.4 Direction by Manager's Representative

1. Manager's Representative will provide inspection staff that will provide technical direction of the grouting operations. Technical direction will be limited to the selection of:

- grout pressures
- mix proportions

- duration and rate of injection
- sequence and layout of grout holes
- depth of packer settings
- refusal criteria.

2. Contractor will provide all other direction and supervision necessary to perform Work in accordance with the drawings and specifications.

3. Perform grouting in presence of Manager's Representative.

3.5 Records

1. Prepare and submit to Manager's Representative completed and signed copies of grouting records for all grouting at the end of each shift.

2. Grouting records include: project name; Manager; name and signature of individual supervising the grouting and record keeping; date(s) and time(s) of all grouting: location and I.D. number of hole; hole diameter; type, number and depth of packers for each grouting increment or stage; water/cement ratio and changes and time of change of water/cement ratio; volume of grout injected for each stage, number of bags of cement injected for each stage, grout wasted; pressure, changes in pressure and time of change; volume of sand or bentonite added, liters of water added to mix; and in general any changes in procedures, pressure, grout takes, mix or equipment that has direct effect on grouting operations.

3. Plot grout data in tabular and graphical form immediately and continuously as data is recorded. This data will be used to evaluate the grouting and to adjust the grouting procedures.

4. Designate each hole a grout hole number defined by the station number as determined by site surveys. Provide a marker at each hole with the hole number clearly and permanently identified.

5. Record losses of drill bits, rods and/or casings in hole and provide description and depth of lost items.

3.6 Mixing

1. Mix grout in a mechanically operated, high-speed colloidal mixer. Provide facilities at the mixer for the accurate measurement of grout materials so that mix proportions can be carefully controlled.

2. Hydrate bentonite for a minimum of 24 hours or as directed by the Manager's Representative prior to incorporating in a grout mix.

3. Inject grout when the temperature of the grout mix is between 5° and 25°C.

4. When grouting is performed in freezing conditions protect materials from freezing throughout the mixing, agitation and pumping period right up to the time of injection. Cover and heat the grout plant and work area around the grout hole.

5. Mix grout in batches of a volume suitable to permit water-cement ratios and composition of grouts to be changed to ensure continuous flow and minimum waste.

6. Mix grout for a minimum of three minutes before injection.

7. Grout that is not injected within one hour of mixing shall be disposed of in a disposal area as designated by Manager's Representative.

8. All mix proportions are specified by weight.

3.7 Grouting Procedures

1. Water pressure test grout holes before grouting as required by Manager's Representative in accordance with specification VM00467-14300-41ES-0015.

2. Thoroughly wash all grout holes immediately before water pressure testing or grouting the hole to remove fines, sludge or foreign materials. Wash by injection of water at the bottom of the hole for five minutes or until return water is clear. Holes grouted within 8 hours of completion of water pressure test need not be rewashed. Return wash water to be collected and disposed of in such a manner as to meet environmental requirements.

3. Grout holes in 5 meter stages from the bottom of the hole upwards using a single packer.

4. Ensure packer is tightly sealed against hole walls and, with regard to upper stage, as close to bedrock surface as possible. If grout or water leak is observed, reset packer properly and re-grout the stage.

5. Inject grout in a continuous operation until specified refusal criteria are achieved in all stages of the hole. If equipment breaks down, flush the hole with water until the return water is clear and regrout the hole.

6. Commence grouting with the primary grout holes on 6 meter centers followed by split spaced secondary and tertiary grout holes as required by Manager's Representative.

7. Additional grout holes may be required according to the results. After grouting primary and secondary holes in a given section, the Manager's Representative will determine the need for additional grouting.

3.8 Grout Mix Selection

1. Grout each stage starting with a stable mix (water/cement ratio between 0.4 and 0.7 by weight with suitable proportions of superplasticizer). As directed by Manager's Representative, maintain or thicken mix depending on injection rate and duration as directed by Manager's Representative.

The use of bentonite if required to stabilize the cement in suspension should be carried out in accordance with directives from the Manager's Representative. When used bentonite must be fully hydrated before adding cement.

2. Inject initial grout mix with grout pump operating at constant speed. If the rate of injection drops steadily, continue with the starting mix until refusal is reached. If the rate of injection is high and does not permit to achieve refusal after the injection of 1,000 liters then decrease the content of superplasticizer and inject successively thicker mixes. Inject each mix for a 10 minute period until the grout injection stabilizes or ref usal is reached.

3. Add sand to the grout mix in areas of high grout takes as directed by Manager's Representative.

3.9 Pressure

1. The required grouting pressure at the mid point of a stage is calculated at plus 20 kPa per meter measured vertically from the top of the grouting platform to the top of rock 25 kPa per meter, measured vertically from the bedrock surface. The minimum pressure required at mid-stage is 75 kPa above the hydrostatic head from water level and the maximum is 1500 kPa.

3.10 Refusal

1. Refusal criteria is 0.2 l/min for 10 minutes at maximum required pressure.

2. Refusal should be reached at the maximum required pressure for the section being grouted or as directed by Manager's Representative.

3. Refusal criteria must comply with section titled Grout Mix Selection.

4. If the grout take is such that it is impossible to reach the specified pressure after pumping a volume of grout corresponding to 2,000 litres or as directed by Manager's Representative, reduce the rate of pumping or stop pumping temporarily and allow sufficient time for the grout to stiffen. Repeat this procedure until refusal is reached. If this procedure is not successful discontinue grouting, allow grout to set and perform additional grouting in the hole or adjacent holes as directed by Manager's Representative.

3.11 Tertiary and Additional Holes

1. Tertiary hole are mandatory additional holes are required when any adjacent hole has a stage that absorbs more than 25 kg/m or when the permeability in Lugeons is greater than 3 Lugeons. The length of any additional hole shall be such as to exceed by at least 5 m the bottom elevation of the stage in which an absorption greater than 25kg/m has been recorded.

3.12 Hole Communications

1. If during the grouting of any hole grout is found to communicate with an adjacent ungrouted hole, place a packer in the latter hole and grout both holes together starting from the bottom until the depth where the communication has been observed or, alternatively, after completing the

grouting of the former hole, wash the ungrouted hole with water until the return water is clear and perform grouting after allowing the initial setting of the grout in the first hole.

3.13 Back Filling

1. On completion of grouting, back fill each grout hole with 0.5:1 grout mix (water/cement by weight) by tremie grouting through a pipe extending to the bottom of the hole.

2. Where grouting has been carried out before cutoff wall construction, backfill a volume of grout sufficient to fill the hole to a minimum height of 5 m above bedrock level.

3. Where grouting has been carried out after cutoff wall construction, backfill the hole to 417.5 m elevation. Over the following hours, regularly check the grout level in the hole and pour additional volume of grout as necessary to ensure complete filling of hole. Report any unusual drop in grout level.

4. Backfill all holes during the same shift as they were grouted. If a series of holes are backfilled at the same time, place a temporary cone at the collar of the same to prevent blockage by falling debris.

3.14 Clean-up

1. Keep grouting areas free of water, grout, sludge oil or deleterious material.

4.0 QUALITY CONTROL

As per QA/QC Plan document.

-END OF SPECIFICATION

AMEC EARTH & ENVIRONMENTAL	Technical Specification **WATER PRESSURE TESTING**	Revision	
		No.	Date
	VM00467-14300-41ES-0015	0	Aug/07

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ATTACHMENT A - WATER PRESSURE TESTING EQUIPMENT CHECK LIST

1.0 GENERAL

1.1 Environmental Protection

1. Comply with the requirements of Specification VM00467-14300-41ES-0002 (Environmental Protection) and of the Water License.

1.2 Submittals

1. Submit water pressure test plan including a list of proposed equipment, a water pressure testing schematic and proposed test record sheets. The schematic is a simple line sketch showing pumps, gauges, valves, hoses, hookups, and all other associated equipment to be used in water pressure testing. An equipment check list is attached at the end of this section (ref. Attachment A).

2. Submit calibration certificates for pressure gauges and flowmeters.

2.0 PRODUCTS

Not Used.

3.0 EXECUTION

3.1 Equipment for Water Pressure Testing

1. Furnish water pressure testing equipment of a type and capacity and in mechanical condition suitable for performing the work satisfactorily.

2. Equipment shall include pumps, piping, pressure gauges, valves, fittings, seal assemblies (packers), and all other accessories. Provide pumps of gear, centrifugal, or other approved type, with an output of not less than 250 liters per minute, and shall be capable of maintaining constant pressures up to 1.5 MPa.

3. Supply water storage tanks having sufficient capacity for the pumps in addition to two sets of flowmeters and Bourdon gauges for calibration and checking purposes.

4. The packers or seals to be of the multiple leather cup, mechanically expanded rubber ring, or pneumatically expanded rubber sleeve type capable of sealing holes at any specified level to a maximum depth of 50 m without leakage. Provide packers capable of being used either singly or in pairs, separated by up to 3 m of perforated pipe. The diameter of the pipes used for separating the packers and for placing the packers in holes shall be the maximum practical for the size of the hole. The packers shall be capable of withstanding the maximum gauge plus existing water column pressure without leakage for a period of 10 minutes.

3.2 Water Pressure Testing

1. Manager's Representative to witness water pressure testing for grouting.

2. Thoroughly wash each hole under pressure immediately before pressure testing to remove any accumulation of fines, sludge, or foreign materials. Wash holes by injection of water at the bottom of the hole for five minutes or until the return water is clear.

3. Water pressure testing in sections shall be carried out as required by Manager's Representative. Each section shall be isolated by means of two packers spaced a maximum distance of 3 meters apart. Closer spacing of packers may be required by Manager's Representative to isolate leakage zones near the top of rock. For each section, back pressure shall be measured at the collar of the hole with the hole full of water. Water pressure shall then be applied to the section for a minimum period of 5 minutes and the volume of water inflow shall be measured to the nearest liter and recorded.

4. Manager's Representative will determine water pressure to be applied to test section. Generally the maximum effective water pressure at the mid point of a stage is calculated at 25 kPa per meter of depth measured vertically from the bedrock surface. The minimum pressure is 75 kPa (or hydrostatic head created by the water column in the test apparatus) and the maximum is 1500 kPa.

5. Perform tests in five pressure increments 1/3, 2/3, 1, 2/3, 1/3 times maximum pressure. Hold each pressure increment for 5 minutes. Measure flow for each 5 minute period.

6. Check for flow out of the hole at the collar or for rise in water level in the hole during the test as this indicates leakage around the packers. If leakage is confirmed, stop the test, reset the packers and retest.

4.0 QUALITY CONTROL

4.1 Type and Frequency of Testing

1. Perform water pressure testing in holes at a minimum frequency of one hole per every 10 grouting holes.

4.2 Report

1. Submit copies of completed and signed water pressure test records to Manager's Representative within 24 hours of test completion.

2. Water pressure test records including project name, name and signature of tester, date and time of test; location and number of hole; hole diameter; drill type, number, type and depth of packers for each test; water meter readings at beginning and end of each increment; gauge pressure for each increment; remarks relating to testing including problems, special observations etc.

ATTACHMENT A

WATER PRESSURE TESTING EQUIPMENT CHECK LIST

Guages:	Number of	_____	Number of	_____
	Range 0 to:	_____kPa	Range 0 to:	_____kPa
	Type:	_____	Type:	_____
	Manufacturer:	_____	Manufacturer:	_____
	Diameter:	_____mm	Diameter:	_____mm

Water Meter: Type:_____

Reading Accuracy:_____ liters

Packers: Type:_____

Size:_____

If gas filled, max. inflation pressure:_____kPa

Water Pump: Type:_____

Capacity: litres/min. kPa

_____ _____

Model:_____

Manufacturer:_____

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1.0 GENERAL

1.1 Reference Standards

1. American Society for Testing and Materials ASTM C109 - Test for Compression Strength of Hydraulic Cement Mortars (Using 2 in or 50 mm Cube Specimens).

2. Canadian Standards Association CAN/C SA-A23.1 - Concrete Materials and Methods of Concrete Construction.

1.2 Environmental Protection

1. Comply with the requirements of Specification VM00467-14300-41ES-0002

1.3 Submittals

1. Submit drilling plan including

   a) Methods of drilling in rock, overburden, rockfill and cutoff wall for curtain grouting, instrumentation and exploration work if required.

   b) Equipment lists of drills, compressors and other specialty equipment, including type, condition, model and number on site.

   c) Layout and sequence of work.

   d) Method for measuring inclination/orientation of boreholes.

1. Submit drill log templates to Manager's Representative for approval.

2.0 PRODUCTS

Not used.

3.0 EXECUTION

3.1 Drilling Equipment

1. Provide all drilling equipment of adequate type, size, number and capacity and in mechanical condition suitable for performing work satisfactorily.

2. Use drilling techniques that can drive casing and drill bit simultaneously and/or where required, rotary core drilling with continuous core recovery in cutoff wall and in bedrock.

3. Equipment must be capable of achieving the hole size, inclination and drilling tolerance specified.

4. Except for core drilling, provide drills with instruments that continuously monitor drilling speed, thrust on drill rods, water/air pressure or other useful parameters during drilling with a view to accurately locating the bedrock surface.

5. Provide all necessary equipment to measure the inclination and orientation of the boreholes.

3.2 Drilling

1. Manager's Representative will witness drilling.

2. Locate and drill holes in the sequence, orientation, and to the depths as shown on the drawings, or as required by Manager's Representative.

3. Do not use rod dope, drilling mud, excessive grease or other lubricants as an aid to drilling grout holes and instrumentation holes. Wipe excess grease from outside of rod or casing joints.

4. Protect each hole from clogging or obstruction by means of a temporary cap or other suitable means at the collar. Clean out any hole that becomes clogged or otherwise obstructed before completion in a manner acceptable to Manager's Representative or drill another hole at no additional cost to Owner.

5. Do not drill grout holes within 12 m of another hole that is being grouted or that has been grouted within the previous 24 hours.

6. Do not perform re-drilling of a hole until the grout last pumped in the hole has achieved initial setting.

7. Do not perform drilling in the cutoff wall until at least 7 days after completion of the cutoff wall.

8. Grout holes shall have a minimum 50 mm diameter.

9. Verification core holes in cutoff wall shall be drilled using triple tube core barrels recovering minimum S size core diameter.

10. In core holes, use suitable drilling fluid and/or additives to maximize core quality and recovery.

3.3 Tolerance on Drill Holes

1. The maximum allowable offset measured at the collar of all drill holes in any direction is 50 mm.

2. The drill hole deviation, at any point along the drill hole and in any direction, with respect to the orientations specified on drawings, shall be less than 1.0% of the hole length at that point.

3.4 Casing

1. Except for rotary core drilling in the cutoff wall, install steel casing over the whole length of all holes drilled in the dike fill, overburden and cutoff wall and anchor steel casing a minimum of 0.5 m into bedrock.

2. For rotary core drilling in cutoff wall, install a starter casing tightly sealed/grouted at hole collar to avoid erosion and other damage to the top of the cutoff wall. Ensure return water does not accumulate and pond at hole collar.

3. Casing size to be compatible with drilling methods, required hole size and drilling tolerances.

4. Provide flush jointed casing complete with cutting bits and shoes necessary for installation.

5. While drilling in overburden, boulders and rockfill, maintain casing cutting edge in close proximity to the drill bit at all times to ensure hole stability.

6. When drilling through the cutoff wall, limit water/air pressure to safe levels to avoid damage to the cutoff wall. Use drill bits which permit evacuation of the maximum aggregate size without damage to the wall or oversize of the hole.

7. Progressively withdraw casing as hole is backfilled.

8. Keep bottom of casing below surface of backfill as the casing is withdrawn.

3.5 Water for Drilling and Washing

1. Fresh water, clean and free of oil, silt, organic matter, alkali, acids, salts and other impurities and conforming to the requirements of CAN/CSA-A23.1

2. Provide adequate water storage facilities to ensure a continuous supply of water for washing drill holes.

3.6 Washing of Holes

1. Thoroughly wash all holes immediately before grouting the hole or installing instrumentation to remove fines, sludge or foreign materials. Wash by injection of water at the bottom of the hole for five minutes or until return water is clear.

2. Return wash water to be collected and disposed of in such a manner as to meet environmental requirements.

3.7 Hole Deviation

1. Use down hole directional survey equipment for measuring hole deviation capable of making inclination measurements in two orthogonal axes parallel and perpendicular to the cutoff alignment. The probe shall fit tightly into the casing and descend the entire length of the holes.
2. Check calibration of the survey equipment at start of work in presence of Manager's Representative and verify bi-weekly thereafter in a reference hole maintained for the duration of the work.

4.0 QUALITY CONTROL

4.1 Calibration

3. Provide calibration certificates for all instruments installed on the drills to monitor drilling parameters. Certification to indicate that the test equipment used for this purpose is calibrated and maintained in accordance with the manufacturer's calibration requirements. Calibration certificates to be provided for the following instruments:

    a) Drilling Instruments:

    - Drilling advance
    - Thrust on drill rods
    - Water/air pressure
    - Any other useful parameter

    b) Borehole Surveying Instruments

4.2 Verification Core Holes

1. Perform vertical or inclined verification coreholes by continuous coring to obtain samples of plastic concrete, jet grout, curtain grout and rock to a minimum depth of 2 m into bedrock. Use of Geobor S size triple tube core barrel or approved equivalent is mandatory. Place cores in core boxes, protect from freezing and deliver to Manager's Representative.

2. All coreholes are to be provided with a starter casing tightly anchored and sealed in the cutoff wall to prevent damage to the same.

3. All coreholes in the cutoff wall are to be backfilled while simultaneously withdrawing the drill casing. Use of the tremie method and an approved non- shrink grout (curtain grout, jet grout or approved alternate) is mandatory.

4. As directed by Manager's Representative, perform unconfined compression testing, density, etc. on selected core samples. Samples to be tested on a priority basis to avoid drying/curing effects following sample retrieval.

4.3 Report

1. For grout holes, submit copies of completed and signed drill hole logs to Manager's Representative within 24 hours of hole completion.
2. Include on drill logs:

    a) identification number of hole

    b) date and time of start and finish

    c) names of driller and helper

d) drill rig model and manufacturer

e) type, diameter of drill bit and casing

f) total depth of hole

g) material interfaces identified by driller (fill/till, till/rock, etc.)

h) observations on water loss and return

i) any remarks or observations of the drilling that relate to progress, down time, equipment breakage, etc., that affect the drilling.

3. For core holes, submit the following within 24 hours of hole completion:

   a) detailed geologic description of all materials encountered (plastic concrete, jet grout, curtain grout, rock, zones of untreated soil inclusions, poorly mixed material, cavities etc), RQD, percentage of core recovery, detailed rock joint description, etc. Ensure uniform terminology is utilized.

   b) digital color photographs of cores at reasonable scale and under adequate light conditions such that core details and hole number, depth marks and a graphical scale (measuring tape for example) are clearly visible. Wet core as necessary to enhance contrasts.

   c) Drawings showing both in plan and section the location of the core holes in respect to the diaphragm wall panels and jet grout columns.

4. When required, cooperate with Manager's Representative in carrying out borehole camera survey of the holes. Addition of flocculating agents in the holes may be requested by Manager's Representative to help clarify the water standing in the holes.

5. As directed by Manager's Representative, perform simple pump out tests to determine material permeability and submit measurements/observations within 24 hours of test completion.

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1.0 GENERAL

1.1 Climatic Conditions

1. See the «Site Conditions» specification no. 015803-3120-41EF-0001 (?) for information.

1.2 Environmental Protection

1. Comply with the requirements of Specification 015803-31 20-4EEF -0002 (?) «Environmental Protection» and of the Water License.

1.3 Reference Standards

1. American Society for Testing and Materials.

   a) ASTM C136 - Test Method for Sieve Analysis of Fine and Coarse Aggregates.

   b) ASTM C518 - Test for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter.

   c) ASTM D638 - Test Method for Tensile Properties of Plastic.

   d) ASTM D1248 - Specification for Polyethylene Plastics Molding and Extrusion Materials.

   e) ASTM D1505 - Test Method for Density of Plastics by the Density-Gradient Technique.

   f) ASTM D1621 - Test Method for Compressive Properties of Rigid Cellular Plastics.

   g) ASTM D1622 - Test Method for Apparent Density of Rigid Cellular Plastics.

   h) ASTM D2856 - Test Method for Open Cell Content of Rigid Cellular Plastics by the Air Pycnometer.

   i) ASTM D2842 - Test Method for Water Absorption of Rigid Cellular Plastics.

   j) ASTM D3574 - Method of Testing Flexible Cellular Materials - Slab, Bonded, and Molded Urethane Foams.

   j) ASTM F714 - Specification for Polyethylene [PE] Plastic Pipe [SDR-PR] Based on Outside Diameter.

   k) ASTM D2837 - Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.

   l) ASTM D3350 - Specification for Polyethylene Plastic Pipe and Fittings.

2. American National Standards Institute

   a) ANSI/ASME B3 1.1 - Power Piping.

1.4 Submittals

1. Submit product data sheets and detailed dimensional shop drawings. These documents shall also cover material of construction and performance data. No purchase, fabrication nor installation shall be done without the Manager's Representative approval.

1.5 Record Drawings

1. Provide record drawings on project completion.

2. Provide installation, maintenance and operation instructions covering the whole supply, including a trouble shooting section.

1.6 Tools and Spare Parts

1.6.1 Tools

1. If assembling or dismantling of components supplied under this contract requires the use of special tools, include them as part of the supply. Clearly describe each tool in the proposal.

1.6.2 Spare Parts

1. Propose a list of recommended spare parts. Indicate the quantity that should be kept in stock on site.

2. The Manager reserves the right not to purchase the recommended spare parts.

3. All spare parts shall be identical to the original components and shall be appropriately packed, clearly identified and ready for long term indoor storage.

2.0 PRODUCTS

2.1 General

1. All equipment included in the supply shall be new and of premium quality. Models shall be current with published rating and readily available replacement parts.

2. Standardize the components in order to minimize the number of spare parts required. All similar parts shall be made interchangeable and quickly replaceable.

2.2 Piping System

1. Preinsulated piping system (for heat tracing by others)

    a) «Sclairpipe» as manufactured by KWH Pipe (Canada) Ltd., with heat tracing conduits, insulation and outer jacket by Urecon Insulation Ltd. or equal.

2.3 Identification

1. Identify the supply using the same numbering and abbreviation system shown in the drawings.

2. Affix identification plates and nameplates to all components of the supply.

3. Nameplates shall give the name of the manufacturer, model number, serial number and operating information.

4. Identification plates and nameplates shall be submitted for the Manager's Representative approval.

2.4 Core Pipe

1. Materials

    a) Pipe manufactured from polyethylene resin compound qualified as Type III. Category 5, Class C, Grade P34 in ASTM D1248 with a long term hydrostatic strength of 1600 psi (11030 kPa), when tested and analyzed in accordance with ASTM D2837.

    b) Raw material shall contain minimum 2 percent carbon black.

    c) The pipe shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same specification from the same raw material supplier.

    d) Certify compliance with the requirements of this specification in writing by the pipe supplier.

    e) The cell classification shall be PE345343C for PE 3408 materials per ASTM D3350/F714.

2. Pipe long term hydrostatic design pressure 5516 kPa [800 psig].

3. Pressure rating: Ø 10": DR1 1
   Ø 14" and Ø 16": DR13.5
   Ø 18": DR15.5

4. Fittings to be thermal butt fusion type from the same type and grade of material as the pipe.

5. Flange fittings to consist of butt fused stub end, ductile iron backing flange, red rubber gasket, 304 stainless steel stud bolts and 303 stainless steels nuts.

6. Join pipe and fittings by thermal butt fusion or flange to suit equipment or provide means of disassembly.

2.5 Heat Tracing Conduits

1. Each conduit to be one piece extruded molding applied to the pipe prior to the application of insulation. Install a sufficient number of conduits to meet the pipe heat loss requirement.

2. Securely fasten the conduit to the core pipe, provide 2" (51 mm) aluminium foil tape interface between pipe and channel to disperse heat, and seal to prevent the ingress of insulation.

3. Provide a spare conduit adjacent to each of the specified conduits. Space conduit pairs equally around the bottom half of the pipe (for required number of heating circuits, see heat tracing section in the «Electrical Systems and Equipment» Specification no. 015803-3170-47EF-0004).

4. Check each conduit after insulation to ensure it is not blocked. Seal ends to prevent foreign materials from entering before installation of heating cable.

5. Manufacturer to ensure conduit size is compatible with the cable selected, so that cable may be pulled with relative ease.

6. Coordinate with heat tracing cable supplier and provide pull string in each conduit if required.

2.6 Factory Applied Insulation

1. Clean pipes of surface dust or dirt and treat if necessary to assure positive bond of the foam insulation to entire pipe surface. Sandblast outside surface of core pipe and inside surface of jacket to provide perfect adhesion between HDPE and insulation.

2. Material: rigid polyurethane foam insulation factory applied, closed cell, and void free.

3. Insulation thickness: consult casing size chart in Appendix A.

4. Density: to ASTM D1622, 35 to 46 kg/m^3.

5. Closed cell content: to ASTM D2856, 90% minimum.

6. Water absorption: to ASTM D2842, 4% by volume.

7. System compressive strength (modified ASTM D1621 with casing jacket) approximately 1372 to 2058 kPa (varies with pipe diameter).

8. Thermal conductivity: to ASTM C5 18, 0.020 to 0.026 W/m°C.

9. Service temperature range: -45°C to 85°C.

10. Centering: ±6.35 mm on ends, ±9.55 mm at center (up to 24", above 24" consult manufacturer).

11. Protect all exposed ends of insulation from moisture and sunlight by coating with a 3 mm minimum thickness of water proof sealant prior to leaving the factory.

2.7 Jacket

1. Factory jacket for buried/above ground installation.

2. Material: Type PE black high density polyethylene, UV inhibited, Type III, Class C, Category 5, Grade P34 resin per ASTM D1248.

3. Density: to ASTM D1505, 945 kg/m^3 compounded.

4. Sealant: synthetic polymers or modified rubber mastic.

5. Jacket thickness: consult casing size chart in Appendix A.

6. Elongation: to ASTM D638, (Type IV), 800%.

7. Tensile strength to ASTM D638 (Type IV), 22000 kPa.

8. Service temperature: -45°C to 120°C.

2.8 Insulation Kits for Pipe Joints

1. Urecon Mec-Seal HDPE cased insulation joint kit consisting of extruded high density polyethylene (HDPE) casing with two layers of adhesive factory applied; a hot melt adhesive for sleeve to casing bond and a mastic adhesive for water proofing.

2. Preformed rigid polyurethane halves: properties as described for factory applied insulation.

3. Sealant: apply waterproof mastic sealant on all exposed insulation after field cutting or trimming.

2.9 Insulation Kits for Fittings

1. Fitting insulating kit, consisting of rigid polyisocyanurate or urethane half shells with fully bonded polymer protective coating on all surfaces including ends, stainless steel attachment straps and clips, silicone

2. caulking for seams, and heat shrink sleeves for ends, to be prefabricated in the factory for installation on site. Insulation thickness for fittings to match insulation thickness of the piping.

3. Material: rigid polyisocyanurate or urethane foam insulation factory formed, closed cell, and void free.

    a) Insulation thickness: same as pipe, consult casing size chart in Appendix A.

    b) Density: to ASTM D1622, 27 to 32 kg/m3.

    c) Closed cell content: 90% minimum.

    d) Water absorption: to ASTM D2842, 4% by volume.

    e) Compressive strength: to ASTM D1621, 130 to 160 kPa.

    f) Thermal conductivity: to ASTM C518, 0.027 W/m°C.

    g) Service temperature range: -45°C to 85°C.

4. Polymer coating: to ASTM D35474.

    a) Two component high density polyurethane coating, black.

    b) Density: to ASTM D1622, 1170 kg/m^3.

    c) Durometer D scale 60.

    d) Tensile strength 11 100 kPa.

    e) Thickness outside surfaces: 1.9 mm(standard)
    Thickness inside surfaces: 0.51 mm

2.10 Insulation Accessories

1. Heat shrink tape for sealing insulation half shells against moisture, flexible and adaptable to installation.

    a) Crosslinked polyolefin backing with hot melt adhesive coating.

    b) Backing thickness: 0.43 mm minimum.

c) Adhesive thickness: 0.76 mm.

d) Tensile strength: 22 750 kPa.

e) Service temperature: -40°C to 60°C.

2. Silicone caulking for joint faces of polymer coated rigid urethane foam insulation kits.

a) Color: black.

b) Specific gravity: 1.07.

c) Tensile strength: 2400 kPa.

d) Service temperature: 205°C maximum.

3. Stainless steel bands and band-it clips.

2.11 Valves

1. Provide all valves, as shown on the drawings and as required to operate, maintain and protect the system.

e) Where required for isolation, install gear operated butterfly valves. Supply valves with cast iron body, stainless steel disc and shaft, Buna-N seat, PTFE shaft seals, and ANSI B 16.1 Class 125 flanges.

Acceptable material: Bray, series 31.

b) Where required to exhaust and admit air on the main pipeline, install combination release air valves 50 mm Vent- O-Mat Type RGX. Supplied by Hydro Dynamics Ltd or equal.

The Sewage Air Release & Vacuum Break Valve shall consist of a compact tubular all stainless steel fabricated body, hollow direct acting float and solid large orifice float in H.D.P.E. - stainless steel nozzle and woven dirt inhibitor screen, nitrile rubber seals and natural rubber seat. The valve shall have an integral «Anti-Surge» Orifice mechanism which shall operate automatically to limit transient pressure rise or shock induced by closure to less than 200% valve rated working pressure. The intake orifice diameter shall be 50 mm, equal to the nominal size of the 50 mm valve.

Large orifice sealing shall be effected by the flat face of the control float seating against a nitrile rubber «O» ring housed in a dovetail groove circumferentially surrounding the orifice. Discharge of pressurized air shall be controlled by the seating and unseating of a small orifice nozzle on a natural rubber seal affixed into the control float. The nozzle

shall have a flat seating land surrounding the orifice so that damage to the rubber seal is prevented.

The valve constructio n shall be proportioned with regard to material strength characteristics, so that deformation, leaking or damage of any kind does not occur by submission to twice the designed working pressure.

Connection to the valve inlet shall be facilitated by flanged ends conforming to ANSI B 16.1 Class 125 Standards.

Supply flanged ends with stainless steel screwed studs inserted for alignment to the specified standard.

2.12 Pipe Bedding & Surround Materials

1. Granular material meeting the requirements of Zone 1B in accordance with the specification nº 015803-3120-4GEF-0006 - Embankment for Dikes.

2.13 Backfill Materials

1. Rockfill material meeting the requirements of Zone 2 or 3 in accordance with the specification nº 015803-31 20-4GEF-0006 - Embankment for Dikes.

3.0 EXECUTION

3.1 General

1. Supply all labor, machinery, tools and other material required to complete the installation, adjustment, testing and preparation for commissioning of the equipment in accordance with the rules of the trade.

3.2 Unloading and Handling Pre-Insulated Polyethylene Pipe

1. Unload by hand or by lifting apparatus with fabric slings, do not use cables or chains.

2. Once removed, lay pipes flat on smooth surface, or on sleepers to provide broad bearing surface.

3. Do not drag insulated pipe when moving.

3.3 Repairing Damaged Pipe

1. Repair core pipe by cutting out any damaged sections and rejoin by thermal butt fusion. Repair or reject any gouges, cuts, or scuffs on the surface of the core pipe which are deeper than 10% of the wall thickness.

2. Repair any damage to outer jacket by heat shrink sleeve or heat shrink tape.

3.4 Trenching

1. Do trenching work in accordance with 015803-3120-4GEF-0009 - Excavating, Trenching and Backfilling, and as indicated.

2. Trench depth to provide cover over pipe of not less than 1500 mm from finished grade or as indicated.

3.5 Bedding and Surround Material

1. Place bedding and surround material in unfrozen condition.

2. Place material in uniform layers not exceeding 150 mm compacted thickness up to 300 mm above top of pipe. Compact each layer before placing succeeding layer.

3. Shape bed true to grade to provide continuous uniform bearing surface for pipe exterior. Do not use blocks when bedding pipes.

4. Compact each layer full width of bed with 4 passes of vibrating plate compactor.

5. Fill authorized excavation or unauthorized over excavation below design elevation of bottom of bedding with compacted backfill material.

3.6 Pipe Installation

1. On dry ground, assemble shipping lengths into suitable installation lengths by heat butt-fusion.

2. Use trained personnel and polyethylene pipe butt-fusion jointing machine, approved by the manufacturer of the pipe and fittings.

3. Follow manufacturer installation instructions.

4. Piping to be sloped evenly without pockets toward pumping stations, as indicated.

5. Recheck pipe joints assembled above ground after placing pipe in trench (where applicable) to ensure no movement of joints has taken place.

6. Do not allow water to flow through pipes during construction.

7. Whenever work is suspended, install removable watertight bulkhead at open end of last pipe laid to prevent entry of foreign materials.

8. Complete installation of pipe and fitting joint insulation kits after laying pipe (in trench where applicable) and pressure testing.

3.7 Insulation installation

1. Trim half shells to provide tight fit between ends of factory insulation.

2. No seam to exceed 3 mm in width at any joint. Match outer surface of shell with outer surface of insulation on pipe within ± 6 mm. Shave off any sharp edge with a rasp.

3. Cracks larger than 6 mm to be filled with insulation foamed-in-place. Hold form of galvanized metal sheet over crack with tension straps and spray void with foam until half full. Foam will expand to fill void completely, allow to cure for 15 minutes, trim, remove form, and apply waterproof sealant.

4. Hold half shells in place with masking tape while installing heat shrink sleeves.

3.8 Heat Shrink Installation

1. Install heat shrink sleeves, in accordance with manufacturers instructions, using large broad flame propane torch producing 600 mm flame.

2. Pay special attention to sleeve overlap areas to ensure no voids remain.

3. Install heat shrink tape using single wrap with 1/3 overlap and in accordance with manufacturer's instructions.

3.9 Ancillary Devices

1. Ancillary pipeline devices to be designed to allow for heat tracing. They shall be insulated and protected with outer jacked to the same specification as the adjoining pipe and fittings.

3.10 Backfilling

1. Backfill in accordance with 015803-3120-4GEF-0009 - Excavating Trenching and Backfilling, and as indicated.

2. Construct pipe anchor at prescribed intervals as in dictated on drawings.

4.0 QUALITY CONTROL

4.1 General

1. Conduct all verifications and tests required to demonstrate that the supply is correctly installed, adjusted and ready for commissioning.

2. Provide on site, competent personnel, all of the required equipment, calibrated instruments and accessories to carry out the tests. Remove test material only once the commissioning tests are over.

4.2 Tests and Verification

1. Verify and test the whole supply, including but not limited to, the following:

    - all pipe mounted components to be level and plumb;
    - piping to be aligned with components;
    - check piping slope and correct if pockets are found;
    - check bolt tightening;
    - check sturdiness of supports/guides;
    - pipes and components to be clean (free from debris and dirt);

2. pipe leak testing.

4.2.1 Cleaning

1. At the end of installation, but prior to hydrostatic testing, clean the piping network by water flushing.

2. Such cleaning shall not be done through valves and other pipe mounted components. Clean these components separately. Supply, install and remove all temporary material required for the cleaning operation.

4.2.2 Piping Hydrostatic Tests

1. Run hydrostatic tests prior to the installation of pipe joint insulation.

2. Run hydrostatic tests on all piping in accordance with ANSI/ASME B31.1 Code, CSA B51 standard and the regulations of the NWT.

3. Provide proper means of venting to ensure that the tests are effective.

4. Piping under test shall show no leakage during the inspection period and the test pressure shall show no loss for the duration specified.

5. Defective sections shall be replaced or repaired to the satisfaction of the Manager's Representative.

6. When testing is complete, blow pipes free of water and drain completely.

4.2.3 Air Valves Hydrostatic Tests

1. All combination air release valves supplied shall be subjected to the following testing procedures in the order laid down.

   a) A high pressure strength and leak test whereby the valve is filled with water and pressurized to twice the rated working pressure which shall be held for a period of 2 minutes. Any leaking weeping or sweating shall be reason for rejection.

   b) A low head leak test whereby the valve is filled with water and pressurized to a maximum of 48 kPa using a visible water column connected to the test rig. The valve shall be rejected if leak tightness is not maintained for 2 minutes.

   Each air release valve of the same size and pressure rating must be subjected to a small orifice function test - «Drop Test» - whereby the valve is filled with water, pressurized to above rated working pressure and isolated from the test rig by closure of an isolating valve. A chamber in the test rig immediately prior to the isolating valve must be filled with compressed air at a pressure equal to that being maintained in the air release valve.

   The isolating valve is then opened so as to allow the air to rise in the air release valve without the pressure dropping lower than 207-310 kPa above rated working pressure of the air release valve. The «Drop Test» is then carried out by slowly bleeding off the pressure through a suitable cock until rated working pressure is reached and the float drops away from the orifice to allow discharge. Failure of the air release valve to function in the manner described will be reason for rejection.

   The manufacturer shall provide batch certificates of test compliance which shall be cross referenced to serial numbers indelibly marked onto the identity of each valve.

4.3 Program

1. Prepare and submit, for the Manager's Representative approval, a detailed program of test procedures.

2. The Manager's Representative reserves the right to witness any tests. Advise the Manager's Representative at least 10 working days prior to the start of such tests.

4.4 Instrumentation

1. Calibrate and verify all instruments prior to the tests. Provide proof of calibration as part of the test and verification reports.

2. Gauge pressure range shall be in the order of 1.5 times the test pressure applied.

4.5 Tagging

1. Submit procedures and tagging methods as part of the program of test procedures.

2. Supply and install colored tags to identify the components that have been verified and tested. Each tag shall be signed and dated by the Contractor's Representative.

4.6 Reports

1. Prepare and keep accessible in files all tests and verification reports for all components tested. Submit four (4) copies of each test and verification report to the Manager's Representative for approval.

-END OF SPECIFICATION

AMEC EARTH & ENVIRONMENTAL	Technical Specification **DIKE DEWATERING**	Revision	
		No.	Date
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1.0 GENERAL

1.1 Environmental Protection

1. Comply with the requirements of Specification 015803-31 20-4EEF -0002 «Environmental Protection» (current no?) and of the Water License.

1.2 Climatic Conditions

1. See the «Site Conditions» specification no. 015803-3120-41EF-0001 (current no. ?) for information.

1.3 Submittals

1. Submit a dewatering plan, and include:

    a) description of pumping arrangements,

    b) specifications for pumps,

    c) details of floating equipment platforms,

    d) details of power supply arrangement and power requirement,

    e) description of methods to move pumps within the dike area,

    f) description of methods of access to move and remove pumps and pipelines within the dewatered areas.

2. Submit:

    a) design criteria for dewatering including schedule and design temperature for pump and pipeline design,

    b) design and shop drawings of pumping arrangement,

    c) design and shop drawings of pipelines,

    d) design and shop drawings of barges and anchoring system;

    e) design and shop drawings of diffuser for discharge to Lac de Gras;

    f) procedure for water quality monitoring, including water sampling equipment and methods for TSS and turbidity testing.

1.4 Design

1. Design system to dewater area enclosed by the A21 dike in accordance with the water quality requirements and schedule referenced below.

2. Estimated volume of water:

    - 10 x 106 m3 (To be confirmed, A21 slightly smaller than A418?)

    Volume of water to be pumped shown above was estimated based on the following:

    - Lake surface elevation of 415.8
    - Bathymetric survey of lakebed.
    - Precipitation and runoff during dewatering of 90 mm rainfall during 6 weeks of dewatering.

3. Design pumping equipment to ensure adequate pumping capacity so as to be able to complete dewatering in 6 weeks or less.

4. Design system to minimize disturbance of lake bed sediments and thus manage water quality in the area retained by the A21 dike.

5. Design pump and pipeline system to discharge water directly to Lac de Gras, or the Sediment Containment pond with a suitable valve system to direct water from one discharge point to the other.

6. Design barge systems to provide floating working platforms for pumps and generating units as required. Platforms to be capable of movement up to 100 m range to reach optimum locations for discharge water quality and topographic low points for complete dewatering. Design anchor system to resist wind, roads and hydraulic and mechanical forces.

7. Design a temporary road system in the lakebed to move and remove barges, pumps, pipelines and ancillary equipment when dewatering is complete.

8. Design temporary diffuser for discharge of clean water directly to Lac de Gras. Approximate location is shown on drawings. Adjust as necessary. Diffuser shall permit discharge up to maximum pump capacity without disturbance of sediments. Design anchor system to resist wind, lake currents and hydraulic forces.

1.5 Power Supply

1. Construction power, 600 V/3 ph/60 Hz for site offices and ancillary usages shall be provided by Manager at location as designated by Manager's Representative. Contractor to provide all control, protection, and distribution from this location to his equipment. All power requirements for the dike dewatering shall be supplied by the Contractor.

2.0 PRODUCTS

Not applicable.

3.0 EXECUTION

3.1 General

1. Commence dewatering after cut off wall and grouting have been completed, after plastic concrete in cut off wall has achieved 14 day strength requirements and after the installation of piezometers, inclinometers and relief walls has been completed on dikecrest.

2. Delay start of pumping if high winds are predicted.

3. Pump at a rate such that the water level surface is lowered by maximum average of 400 mm per day. Plan for four days of pumping at a drawdown rate of 500 mm per day followed by a 24 hr period of zero pump discharge. Manager's Representative may require the rate of dewatering to be reduced or may permit it to be increased based on instrumentation monitoring of dikes, pipeline constraints, containment availability and visual observation of the dikes and shorelines.

4. Move pumps or install secondary portable pumps to low points within dike retention area to provide complete dewatering of all areas.

5. Provide spare pumps and parts to ensure that pumping can be performed continuously at a rate sufficient to meet the dewatering schedule requirements.

6. Protect dewatering equipment from freezing and maintain fully operational in freezing conditions down to the design minimum temperature.

7. On completion, remove from site all materials and equipment.

3.2 Water Quality

1. Discharge water from within the A21 dike into Lac de Gras at location shown in drawings and as per the limits specified by the Water License. Water not meeting this requirement shall be pumped to the Sediment Containment Pond or the North Inlet as directed by Manager's Representative.

2. Monitor total suspended solids as per the approved sampling plan.

3. Move intake (up to 100 m range) as directed by Manager's Representative to maximize volume of water (meeting the required water quality standards) which can be discharged directly to Lac de Gras.

4. Adjust depth of submergence of pump intakes to maximize the volume of pumped water meeting the required water quality standards.

3.3 Water Level Monitoring

1. Install water level monitoring gauge and record water level every 24 hours while dewatering. Move gauge as necessary to measure water level as shoreline recedes.

2. Keep monitoring gauge free of ice.

3.4 Additional Pumping

1. Provide additional submersible pumps to pump water from isolated pond areas to main pumping locations.

2. Provide temporary construction dewatering in the dike retention area until the long term water handling system is installed and in operation and permanent works are completed.

3.5 Access

1. Provide access for operating and maintaining all pumps, platforms, pipelines, and ancillary equipment during dewatering and until system is decommissioned.

2. Provide access roads within dike retention areas for access to pumps, pipelines and power cables.

3. Provide boat access to floating equipment platforms at all times during dewatering.

3.6 Acceptance

1. Initial dewatering shall be considered complete when no more than 0.5 m depth of water remains in any areas of the dike retention area. Subsequent dewatering for removal of runoff and seepage will be classified as temporary construction dewatering.

4.0 QUALITY CONTROL

4.1 Testing

1. Monitor water quality and water levels on a regular basis.

4.2 Report

1. Provide water quality monitoring data daily.

2. Provide water level measurements at least once per shift.

-END OF SPECIFICATION

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1.0 GENERAL

1.1 Climatic Conditions

1. See the «Site Conditions» Specification no. 015803-3120-41EF-0001 (current no.? for information.

1.2 Reference Standards

1. This section shall be read together with the «Electrical Systems and Equipment» Specification no. 015803-3170-47EF-0004 (current no.?), which forms an integral part of this specification.

2. American Society for Testing and Materials.

    a) ASTM A-48 - Specification for Gray Iron Castings.

3. Canadian Standards Association.

    a) CAN/CSA-C22.2 No. 108 - Liquid Pumps.

1.3 Submittals

1. Submit product data sheets and detailed dimensional shop drawings. These documents shall also cover material of construction and performance data. No purchase, fabrication nor installation shall be done without the Manager's Representative approval.

1.4 Record Drawings

1. Provide record drawings on project completion.

2. Provide installation, maintenance and operation manual covering the whole supply, including a trouble shooting section.

1.5 Tools and Spare Parts

1.5.1 Tools

1. If assembling or dismantling of components supplied under this contract requires the use of special tools, include them as part of the supply. Clearly describe each tool in the proposal.

1.5.2 Spare Parts

1. Propose a list of recommended spare parts. Indicate the quantity that should be kept in stock on site.

2. The Manager reserves the right not to purchase the recommended spare parts.

3. All spare parts shall be identical to the original components and shall be appropriately packed, clearly identified and ready for long term indoor storage.

2.0 PRODUCTS

2.1 General

1. All equipment included in the supply shall be new and of premium quality. Models shall be current with published rating and readily available replacement parts.

2. Standardize the components in order to minimize the number of spare parts required. All similar parts shall be made interchangeable and quickly replaceable.

3. All graduations and markings on instruments shall conform to the international system of units (SI).

2.2 Identification

1. Identify the supply using the same numbering and abbreviation system used on the drawings.

2. Identify the instruments according to ISAS5.1 standard.

3. Affix identification plates and nameplates to all components of the supply.

4. Nameplates shall give the name of the manufacturer, model number, serial number and operating information.

5. Identification plates and nameplates shall be submitted for the Manager's Representative approval.

2.3 Sumps

1. Provide prefabricated insulated single compartment fiberglass tanks with all ancillaries, generally as shown on the drawings.

2. Design sump floor to withstand full ground pressure and provide rigid mounting for discharge

3. connections. Base corners to be radiused with filament winding process providing an integral base to shell joint.

4. Construct sump walls of resin saturated filament wound fiberglass 60 to 70 percent glass content, reinforced to provide the required strengths with minimum weight.

5. Provide a corrosion liner consisting of a surface veil and two layers of chopped strand mat with 20 to 30 percent non-continuous glass fiber by weight, minimum thickness of 2.8 mm.

6. Construct cover and hatches similar to shell with reinforcing around hatch openings, assemble with stainless steel hardware.

7. Provide two service hatches in the sump roof, hatches to be insulated and watertight.

8. Finish interior with a white gelcoat.

9. Protect insulation with a watertight fiberglass outer jacket. Finish exposed portion, cover and top three feet of buried shell, with green gelcoat.

10. Provide sump with two dike toe drain and one water runoff inlet nozzles, one discharge nozzle, three electrical service nozzles, and two ventilation nozzles.

11. Reinforce all nozzles with gussets to the tank wall.

12. Provide all ancillaries for installation of two pumps, e.g. starters, control and monitoring devices, level controls, discharge connections, guide rails, discharge piping, check valves, butterfly valves, pressure and flow instruments.

13. Provide sump with lifting lugs, hold down straps and/or exterior ribs designed to resist uplift pressures, ladder, and service platform. For blower/heater, axial fan, lighting and other electrical services, see the «Electrical Systems and Equipment» Specification no. 015803-3 170-45EF - 0004(current no.?).

2.4 Submersible Pumps

1. Furnish two (2) submersible, vertical, centrifugal, non-clog waste water pumps, with one (1) mix flush valve per sump as shown and in accordance with the applicable codes and standards. The head on the pump varies over a large range, select pump suitable for the following:

    - Rated head 60 m with capacity of 43 L/s
    - Maximum head 65 m
    - Minimum head 15 m

Acceptable material: Flygt Model C-3300 with HT 454 impeller and 66 kW (88 hp) motor suitable for 600 V, three phase, 60 Hz, power supply.

2. Pump to be automatically and firmly connected to the discharge connection.

    a) Guide by no less than two guide bars extending from the discharge connection to the top of the sump and provide intermediate supports for guide bars.

Provide galvanized schedule 40 guide bars.

3. Insulate sump completely with 75 mm closed cell foam.

    a) Seal pump unit to discharge by machined metal-to-metal surfaces engaged by the weight of the pumping unit to provide a watertight contact.

b) Discharge fitting to support pump completely and prevent pump bearing directly on the floor.

4. Casing: Class 35B, gray cast iron to ASTM A-48, with smooth surfaces devoid of blow holes or other irregularities.

5. Impeller: Class 35B, gray cast iron.

   a) Dynamically balanced, double shrouded, non-clogging design.

   b) Impeller to be capable of handling solid, fibrous material, sludge, and other material found in the pumped water.

   c) Vaned impeller to maximize efficiency, capable of passing a minimum 75 mm diameter solid.

6. Provide wear rings to seal between the volute and suction inlet of the impeller.

   a) Drive fit brass wear ring into the volute.

   b) Heat shrink stainless steel wear ring onto the impeller.

7. Provide pump and motor with common C 1035 carbon steel shaft.

   a) Isolated shaft from the pumped liquid.

   b) Fitted shaft with independent tandem mechanical seals located top and bottom of a lubricant chamber.

   c) Locate lubrication chamber between pump and motor casing and lubricate the lapped seal faces at a constant rate.

   d) Provide tungsten-carbide seals with a stationary ring and a positively driven rotating ring.

   e) Seals not to depend on direction of rotation nor require adjustment.

   f) Provide permanently lubricated anti-friction bearings designed for both axial and radial thrusts.

   g) Provide stainless steel nuts (303) and bolts (304) in exposed locations.

   h) Protect metal surfaces, other than stainless steel or brass, in contact with the pumpage with a water resistant coating.

8. Provide a squirrel cage induction type EEMAC B motor in an air filled watertight housing.

   a) The motor horsepower to be non-overloading throughout the entire pump performance curve from shut- off through run-out.

b) Design motor for continuous duty, and to be capable of 15 starts per hour.

c) The motor insulation shall be Class F, rated for 155°C, and built for a temperature rise not exceeding 80°C, over a maximum ambient temperature of 40°C.

d) Design motor with a minimum service factor of 1.1.

e) Design motor for a minimum voltage tolerance of plus or minus 10%.

f) Machine surfaces of critical mating surfaces and fit with Nitrile O-rings. Sealing design to incorporate metal-to-metal contact between machined surfaces, seal will be the result of controlled compression of an O-ring resulting in contact of four sides without requirement for a specific torque limit.

g) Heat shrink stator into the housing with no other fastening devices which require penetration of the stator housing.

h) Design cable entry so that specific torque requirements are not required to ensure a watertight seal. The entry to consist of a compressed elastomer grommet having a close fit against the cable outside diameter and the housing inside diameter.

i) Provided an additional stator lead sealing gland, between the cable entry junction chamber and the motor.

j) Motor and cable to be capable of continuous submergence under 20 m (65 feet) of water without loss of integrity.

k) Provide power and control cable of sufficient length to allow direct connection to the control panel.

l) Stator to incorporate thermal switches in series to monitor the temperature of each phase.

m) Mount leakage sensor at the bottom of the stator housing to detect the presence of water in the stator housing.

9. Water jacket to enclose the stator housing providing adequate heat dissipation for the motor when not submerged.

a) Base cooling on operation with a pumped liquid temperature up to 40°C (104°F).

b) Impeller back vanes to provide the necessary circulation of liquid through the water jacket. (Checked with Peter Kalesnikoff, don't know how this works)

c) Generously size ports and water jacket passages to prevent clogging.

10. For power and control cable see «Electrical Systems and Equipment» Specification no. 015803-3170-47EF -0004 (?).

11. Fit pump volute with hydraulically operated mix flush valve.

a) Valve to divert portion of pumped liquid back to sump during the first 30 seconds of operation.

12. Enclose control panel, controls and monitoring equipment in a corrosion proof EEMAC 4X stainless steel enclosure and provide features described in the «Electrical Systems and Equipment» Specification

13. no. 015803-3170-47EF-0004 (?).

14. Fit pump with a suitable length of chain and cable tether allowing automatic connection of mobile crane.

2.5 Piping and Valves

1. Install all internal pipe, fittings, and valves in the factory prior to shipment.

2. Discharge lines.

a) Install fiberglass pipes rated at 1034 kPa with flanged connections.

b) Install globe style center guided anti-slam check valves rated at 150# with flanged cast carbon steel body, stainless steel trim and BUNA-N seal on seat.

Acceptable material: APCO, series 600.

c) Install gear operated butterfly valves rated at 150#. Supply valves with cast iron body, stainless steel disc and shaft, Buna-N seat, PTFE shaft seals, and ANSI B 16.1 Class 150 flanges.

Acceptable material: Klinger type KDB.

3. Inlet lines.

a) HDPE/fiberglass pipe and fittings.

b) External connections to be a smooth bore as shown on the drawings, suitable for sub-drainage pipe specified in 015803-3 120-4GEF-0010 (current no.?)and for water runoff heat traced and insulated pipe specified in 015803-3170-45EF-0001.

4. Electrical conduits.

a) Provide a sufficient number of fiberglass nozzles for power supply to each pump and the general power service for sump lighting and heating, heat tracing cable system and remote annunciation

5. Ventilation lines.

    a) Use fibreglass pipe and fittings

    b) External connections to be flanged

2.6 Ancillaries

1. Provide full FRP intermediate service platform with hinged access doors, provide all stainless steel hardware.

2. Install full access ladder constructed of marine grade aluminium with non-slip treads.

3. Internal blower heater and axial fan as described in the «Electrical Systems and Equipment» Specification no. 015803-3170-47EF-0004. Air supply and air exhaust dampers 24 V dc to operate in conjunction with blower heater and axial fan. Extend air supply and air exhaust pipes as shown on the drawing. Provide screened supply and exhaust pipes.

4. Finish hold down lugs and lifting lugs with coal tar epoxy.

5. Supply and install anchor bolts to attach sump to concrete pad sized in accordance with sump manufacturers requirements.

6. Supply and install cast-in-place concrete support pad for each sump.

2.7 Flow Meters

1. Provide two (2) full pipe electromagnetic flow meters per pumping station, i.e. one (1) on each toe drain inlet pipe. Each 6” flow tube shall be constructed of sch80 PVC with Viton gaskets and seals and shall incorporate two (2) 316 stainless steel sensors to provide measurement accuracy of 0.5% of the flow rate. Connections shall be ANSI 150# RF flanges. The signal converter shall be watertight type NEMA 4X (IP65) and shall be provided with submersible flow tube type NEMA 4A-6P (IP68) and 12 m cable for connection to the pump controller.

    Acceptable product:

    - Flow tube: ISCO-Unimag UP-06-F-T-V-I-R
    - Converter: ISCO-Unimag 4404.

3.0 EXECUTION

3.1 General

1. Supply all labour, machinery, tools and other material required to complete the installation, adjustment, testing and preparation for commissioning of the equipment in accordance with the rules of the trade. All internal piping, electrical works and ancillaries to be coordinated and mounted in the sump manufacturer's shop prior to shipping.

3.2 Excavation and Backfill

1. Excavate to required elevation and backfill in accordance with 015803-3 120-4GEF-0009 - Excavating, Trenching and Backfilling, and as indicated.

3.3 Concrete Work

1. Do concrete work as shown and in accordance with Specification no015803-3 120-41EF-001 1 - Cast-In-Place Concrete. Size concrete pad and backfill concrete to prevent the pumping station from floating according to manufacturers recommendations.

3.4 Installation

1. Dewater excavation and remove soft and foreign material before placing concrete base.

2. Cast concrete base or place pre- cast base on compacted Zone 1 rockfill.

3. Set unit in bed of cement mortar and anchor to concrete base. Pumping station to be plumb and level.

4. Place and compact unfrozen backfill in layers to suit pipe connections, after approval of Manager's Representative.

5. Install pumps on guide rails and connect to supply pipes.

4.0 QUALITY CONTROL

4.1 General

1. Conduct all verifications and tests required to demonstrate that the supply is correctly installed, adjusted and ready for commissioning.

2. Provide on site, competent personnel, all of the required equipment, calibrated instruments and accessories to carry out the tests. Remove test material only once the commissioning tests are over.

4.2 Tests and verification

1. Verify and test the whole supply, including but not limited to, the following:

    - demonstrate ease of pump installation and removal;
    - all components to be level and plumb;
    - piping with components and with pumps to be aligned;
    - check bolt tightening;
    - check sturdiness of supports;
    - pipe, equipment and the whole pumping station to be clean (free from debris and dirt);
    - pipe leak testing.

4.2.1 Cleaning

1. At the end of installation, but prior to hydrostatic testing, clean the piping network by water flushing.

2. Such cleaning shall not be done through valves, pumps and other pipe mounted components. Clean these components separately. Supply, install and remove all temporary material required for the cleaning operation.

4.2.2 Hydrostatic Tests

1. Run hydrostatic tests on all piping in accordance with ANSI/ASME B31.1 Code, CSA B51 standard and the regulations of the Northwest Territories.

2. Provide proper means of venting to ensure that the tests are effective.

3. Piping under test shall show no leakage during the inspection period and the test pressure shall show no loss for the duration specified.

4. Defective sections shall be replaced or repaired to the satisfaction of the Manager's Representative.

5. When testing is complete, blow pipes free of water and drain completely.

4.3 Program

1. Prepare and submit, for the Manager's Representative approval, a detailed program of test procedures.

2. The Manager's Representative reserves the right to witness any tests. Advise the Manager's Representative at least 10 working days prior to the start of such tests.

4.4 Instrumentation

1. Calibrate and verify all instruments prior to the tests. Provide proof of calibration as part of the test and verification reports.

2. Gauge pressure range shall be in the order of 1.5 times the test pressure applied.

4.5 Tagging

1. Submit procedures and tagging methods as part of the program of test procedures.

2. Supply and install colored tags to identify the components that have been verified and tested. Each tag shall be signed and dated by the Contractor's Representative.

4.6 Reports

1. Prepare and keep accessible in files all tests and verification reports for all components tested. Submit four (4) copies of each test and verification report to the Manager's Representative for approval.

-END OF SPECIFICATION

INSTRUCTION TO DOCUMENT CONTROL

☐ Entire specification revised. Reissue all pages.

☐ Reissue revised pages only

STAMP THE SPECIFICATION AS FOLLOWS:

☐ Issued for comments

☐ Issued for tender

☒ Issued for approval

☐ Issued for purchase

☐ Issued for construction

SPECIFICATION REVISION INDEX

No.	(AMEC) Prepared By Date	(AMEC) Approved By Date	(DDMI) Reviewed By Date	(DDMI) Approved By Date	Pages Revised	Remarks
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1.0 GENERAL

1.1 Climatic Conditions

1. As described in Specification no. 015803-3120-41EF-0001.

1.2 Standards

1. The design, the material, the fabrication, the installation, the inspection and the tests for all electrical equipment, along with all the work included in this specification must comply with the latest edition of the following codes, rules and standards:

- The laws and regulations of the North-West Territories and of Canada
- CAN/CSA-C22.2 No. 0: Canadian Electrical Code, Part II.
- CSA C22.2 No. 0.5: Threaded Conduit Entries
- CSA C22.2 No. 14: Industrial Control Equipment
- CSA C22.2 No. 29: Panelboards and Panelboard Enclosures
- CSA C2232 No. 38: Thermosetting Insulated Wires and Cables
- CSA C22.2 No. 100: Motors and Generators
- CSA C22.2 No. 130: Heating Cables and Heating Cable Sets
- CSA C22.2 No. 131: Type Teck 90 Cable
- CSA C22.2 No. 239: Control and Instrumentation Cables
- NEMA MG1: Motors and Generators
- EEMAC: Electrical and Electronic Manufacturers Association of Canada

In case of discrepancy the most demanding standard shall prevail.

1.3 Submittals

1. The Contractor shall submit to the Manager's Representative the following documents for approval:

- Shop drawings
- Layout drawings
- Installation and details drawings
- Control schematics and wiring diagrams
- Bill of material
- List of cables

2.0 PRODUCTS

2.1 General

1. All material and equipment shall be new, and in accordance to specification requirements.

2. All materials shall be conformed to CSA Standards or equivalent approved by the Manager's Representative.

3. All elements having the same functions shall be interchangeable. All the devices and accessories having the same functions shall come from only one supplier.

2.2 Pumping Station - Pump Motor Control

The Contractor shall supply from pump manufacturer a completely assembled control panel for the operation of two submersible pumps of 88 HP, 600 volts and 3 phase. The control panel shall include but not limited to the following:

1. All electrical power and control enclosures for the pumping system shall be stainless steel EEMAC 4X.

2. A 600 V thermal-magnetic circuit breaker having a fast response, high interrupting capacity and sealed contact chambers with clear covers for inspection to supply the power to the electrical panel of the sump pumps.

3. Two magnetic across-the-line motor starters coupled with soft start control to be used for the operation of the motors.

4. Pump motors to be supplied with submersible SOW cables.

5. Pumps to be controlled in a duplex mode with a piezo-resistive type level sensor, which starts and stops the pumps at preselected levels. Two float level switches detecting low and very high levels of water in the sump are also required to detect abnormal conditions of the pumping system. All three level sensors shall be located in the sump. Each pump shall start alternatively with the possibility of having both pumps running if the water reaches a high level in the sump.

6. The manual/off/automatic pump functions shall be possible with the pump control panel.

7. Sump with low temperature alarm sensor, on drop in temperature below set point, initiate a local alarm light and close dry contact for remote alarm.

8. Waterproof flashing strobe (red lens) local alarm light, with 650 minimum effective candle power to be mounted on top of the pumping station; override switch on local control panel to be provided.

9. A control system providing the monitoring and protection necessary for the continuity of the service with the following characteristics:

    - microprocessor-based control with fault diagnostics and display;
    - protection devices of the pumps with data logging and alarms;
    - monitoring of the high or low levels, the supply pressure and flow, the water leak in the motor, the overload, the supply voltage, phase unbalance and power outage;
    - recording of the operation data such as power consumption, length of time and frequency of operation of each pump;
    - elapsed run time meter to record total running time of pumps.

10. Indicating lights to be provided giving the following information:

    - pump circuit energized (red);
    - pump running (green) ;
    - motor overload (red) ;
    - water leak in the motor (red) ;
    - stator thermal overload (red) ;
    - very high water level (red) ;
    - low water level (red) ;
    - loss of power (red)

11. For the pumping station a dry contact initiated for any of the following conditions shall trigger a general alarm for remote alarm :

    - motor overload ;
    - stator overload ;
    - water leak in a motor;
    - selector switch in the off position;
    - very high water level ;
    - low water level ;
    - loss of power.

12. The control panel shall be equipped with the necessary interface equipment to communicate operational data and alarms to a UHF radio modem.

13. The control panel shall be equipped with a heating element with a thermostat and a 120 V outlet.

14. The control panel shall be from Flygt with a monitoring and control unit MACTEC FMC-200 equipped with the SIOX input and output system and one RIO- S45 module.

2.3 Pipe Heat Tracing Cables

1. The heat tracing cables shall be installed at two different zones which are the discharge pipe and the intake pipe. The design of the heat tracing cable system shall be based on the following criteria:

   Heat tracing cable type:

   - discharge pipe: series resistance (constant watt)
   - intake pipe: mineral insulated with copper sheath
   - Freeze protection temperature: + 10°C
   - Ambient temperature: - 50°C
   - Insulation type (for the discharge pipe): Fluoropolymer dielectric insulation
   - Pipe material: HDPE
   - Pipe insulation: polyurethane with polyethylene jacket
   - Insulation thickness: 70 mm and more (depending on pipe size)
   - Wind speed: 40 km/hr
   - Voltages: 240/120 V, 1 phase
   - Ground continuity (for series and parallel resistance cables): the nickel plated copper braid along the entire length of cable and overall fluoropolymer jacket.

2. The discharge lines shall be supplied at 240 V while the intake lines shall be fed at 120 V.

3. The discharge pipe shall be heated by two series type heat tracing cables fed from a common power point. Each cable shall be controlled with two RTD sensors, a power panel and a control panel.

4. The intake pipe shall be heated with three mineral insulated heat tracing cables. The three cables shall be controlled with two RTD sensors and a control panel.

5. Heat tracing cable systems shall be designed in order that in case of damage to one of the cable, the second heat tracing cable can provide at least 50% of the heat loss capacity and assure that one cable protects the pipe from damage and freezing while the other cable is repaired or ordered.

6. The heat tracing cable of the discharge line shall be spliced in junction boxes at every 100 m.

7. Control panels and junction boxes shall be built as weatherproof enclosures, EEMAC 4X stainless steel with a hinged cover held in place by screw closures. The control for the heat tracing cables shall use a microprocessor-based technology. The operating RTD sensor shall trigger the operation of the cables when the temperature sensed on the HDPE pipe falls below the set temperature and cutoff the power when the HDPE pipe temperature is above the set point.

8. The second RTD sensor shall monitor the temperature at the surface of the pipe. If temperature above 29°C is sensed by the RTD sensor, it shall cut off the power of the corresponding heat tracing cable and initiate an alarm. If a temperature below the set point of the heating cable is detected, an alarm shall be initiated.

9. The heat tracing cables shall be provided with ancillary materials necessary to complete the heat tracing system installation.

10. The control panels shall be equipped with the necessary interface equipment to communicate alarms to the FMC- 200 remote RTU unit of the pump control system.

11. All heat tracing circuits shall be switched with an «ON-OFF» control using a soft start feature consisting of a three minute ramp power application from 0 to 100%. This feature minimizes the effects of start-up power.

12. Pilot lights, mounted on the control panel door, shall be used to indicate the following:

    - Power on
    - Heater on
    - High cable temperature
    - Low pipe temperature
    - Ground leakage current
    - Damaged RTD sensor.

13. For each heat tracing system a dry contact initiated for any of the following conditions shall trigger a general alarm for remote alarm:

    - High cable temperature
    - Low pipe temperature
    - Ground leakage current
    - Damaged RTD sensor
    - Selector switch in the off position (heat tracing system for discharge pipe).

2.4 Electrical Distribution Equipment

The Contractor shall supply the following:

1. Disconnect Switches

Fused disconnect switches shall be of heavy duty type, 600 V a.c., 60 Hz, with copper terminals. They shall be stainless steel EEMAC 4X waterproof enclosure and suitable for wall mounting. Disconnect switches shall be provided with a fast closing and opening mechanism. The operating handle of disconnect switches shall be interlocked with the door and have a padlocking device. Disconnect switches shall be supplied with 600 V, HRC type fuses.

The electrical characteristics and the function of the fused disconnect switches are the following:

- One (1) 3 phases, 400 A with fuses of 300 A for the supply of the splitter trough.
- One (1) 3 phases, 200 A with fuses of 110 A for the supply of the step down distribution transformer and 240/120 V distribution panel.
- One (1) 3 phases, 30 A with fuses of 15 A for the supply of the unit heater.
- One (1) 3 phases, 60 A with fuses of 60 A for the supply of each thermosyphon.
- One (1) 3 phases, 30 A with fuses of 15 A for the supply of each data logger shelter.

2. Splitter Trough

One (1) splitter trough shall be provided for the 600 V distribution in the pumping station. The splitter trough shall be of 600 V a.c., 3 phases, 3 wires, 400 A, with copper bus and equipped with suitable size copper lugs, all housed in a waterproof EEMAC 4X stainless steel enclosure.

3. Distribution Transformer

One (1) distribution transformer shall be provided in the pumping station and in each data logger shelter. The distribution transformer shall be dry type epoxy encapsulated and built for outdoor use. The electrical characteristics of the transformer for the pumping station are the following:

rating:	50 kVA
phase and wire:	single phase, 3 wires
voltage:	600 - 240/120 V
frequency:	60 Hz
temperature rise:	115°C
tap changer:	off load with 4 primary taps 2 x 2 ½% FCAN, 2 x 2 ½% FCBN
winding conductor:	copper

The electrical characteristics of the transformer in each data logger shelter are the following:

rating:	7.5 kVA
phase and wire:	single phase, 3 wires

voltage:	600 - 240/120 V
frequency:	60 Hz
temperature rise:	115°C
tap changer:	off lo ad with 4 primary taps 2 x 2 ½% FCAN, 2 x 2 ½% FCBN
winding conductor:	copper

4. Distribution Panel

One (1) lighting and distribution panelboard shall be provided for the 240/120 V distribution in the pumping station and in each data logger shelter. The panelboard for the pumping station shall have the following characteristics:

- Waterproof EEMAC 4X cabinet
- 240 V a.c. maximum
- Single phase, 60 Hz, 3 wires with neutral
- Main copper bus and main lugs of 225 A
- Minimum short circuit withstand of 10 kA symmetrical
- 24 branch circuits.

The panelboard shall include 14 branch molded case circuit breakers, single pole, 240 V maximum,
10 kA sym interrupting rating and 2 branch molded case circuit breaker, 2 pole, 240 V maximum, 10 kA sym. interrupting rating.

All circuit breakers shall be padlockable in the «OFF» position and have a thermal and magnetic tripping device.

The panelboard for each data logger shelter shall have the following characteristics:

- Waterproof EEMAC 3R cabinet
- 240 V a.c. maximum
- Single phase, 60 Hz, 3 wires with neutral
- Main copper bus and main lugs of 100 A
- Minimum short circuit withstand of 10 kA symmetrical
- 12 branch circuits.

The panelboard shall include 6branch molded case circuit breakers, single pole, 240 V maximum, 10 kA sym interrupting rating and one branch molded case circuit breaker, 2 pole, 240 V maximum, 10 kA sym. interrupting rating.

All circuit breakers shall be padlockable in the «OFF» position and have a thermal and magnetic tripping device.

5. Lighting and Receptacles

   The lighting shall be provided by marine type incandescent lighting fixtures mounted on the walls of the pumping station. The lighting fixtures shall be equipped with globe and guard. The control of the lighting shall be with a wall mounting lighting switch.

   Two 120 V, 15 A duplex receptacle designed for outdoor use shall be provided inside the pumping station.

   Two 120 V, 15 A duplex receptacle designed for outdoor use shall be provided for each data logger shelter.

6. Heating

   The pumping station shall be heated with a heavy duty inline blower heater having a capacity of 10 kW, 3 phases, 600 V. The blower heater shall include fan, heat exchanger, heat sensor and control panel. This latest shall comprise controller, relays, control transformer and temperature sensor. An axial fan shall be provided near the service floor in order to provide an additional air blow toward the water
   reservoir.

   Each data logger shelter shall be heated with a heavy duty convection heater having a capacity of 3 kW, 1 phase, 240 V equipped with a thermostat.

7. Cables

   Multiconductor power cables for 600 V and 240/120 V shall be Teck90, FT4, -40°C, 1000 V and 600 V respectively, copper conductor with XLPE insulation type RW90, aluminum armour and PVC outer jacket. Cables shall be as per CSA C22.2 no. 131.

   Armored multitriad cables for RTD connection, 16 AWG, copper conductor, 600 V, PVC insulation TW75, FT4 with aluminum armour and PVC outer jacket (90 °C, - 40 °C). Cables shall be as per CSA C22.2 no. 239.

3.0 EXECUTION

3.1 General

1. This section covers the requirements for the supply of material, labour, tools, services and supervision as required for the installation of the electrical systems.

2. The works include for the pumping station the installation and connection of the:

    - Power distribution equipment;
    - Alternating sump pumps system;
    - Lighting, heating and receptacles;
    - Cabling and grounding.

3. The works also include for each data logger shelter the installation and connection of the:

    - Power distribution equipment;
    - Lighting, heating and receptacles;
    - Cabling and grounding.

4. The works also include the installation and the connection of the heat tracing system and the connection of the electrical equipment associated with thermosyphons.

5. The electrical equipment shall be located above the maximum water level of the retention pond. The electrical equipment shall be located inside the pumping station.

3.2 Identification

1. All electrical equipment shall be clearly identified with its equipment number, function and voltage.

2. Each circuit in the distribution panel shall be identified. All cables in panels and junction boxes shall be tagged at both ends with the cable number assigned in the cable schedule.

3.3 Installation

1. Power Distribution Equipment

    The Contractor shall supply and install all required corrosion resistant brackets or plates to hold transformers, disconnect switches, distribution panels, control panels and other equipment that will be wall mounted and to provide an installation that is true, plumb and safe.

    The Contractor shall follow the Manufacturer's instructions for the installation, wiring, testing and energizing of the equipment.

2. Lighting and Receptacles

Lighting fixtures shall be installed plumb and true. Fixtures shall be installed only after all work that might damage or soil the fixture, the lamp or the globe has been completed.

All lamps shall be supplied and installed by the Contractor.

The lighting switch shall be properly located with reference to the ladder position and the entrance of the pumping station and shall be surface mounted.

Receptacles shall be surface mounted on the wall.

3. Heating

The Contractor shall execute all the required works for the installation and the connection of the inline heater blower and the axial fan in the pumping station and of the heavy duty convection heater in each data logger shelter. The Contractor shall install and connect the equipment in accordance with Manufacturer's instructions.

4. Cables

The Contractor shall follow the Manufacturer's instructions concerning:

- cable pulling and installation;
- cable installation under cold temperature;
- bending radius;
- pulling tension;
- any additional recommendations specified for cable installation

The Contractor shall attach armored cables at every meter by means of corrosion resistant strap.

All power cables shall be run full length without splices and shall be continuous from origin to termination. Where splices are necessary and approved, they shall be made in approved splice boxes with suitable connectors.

Termination of jacketed armored cables shall be made in suitable watertight cable connectors. These connectors shall terminate and ground the armor, support the cable and provide a waterproof entry to
the equipment.

Conductors shall be terminated on terminal blocks.

5. Grounding

Grounding shall be provided for all motor frames, housing of control equipment, transformers, transformer neutrals, panels, distribution equipment and other similar equipment, as required by the Canadian Electrical Code.
The contractor shall supply and install copper conductors, connectors, lugs and other required accessories for the grounding.

6. Pipe Heat Tracing Cable

   The Contractor shall install and connect the heat tracing cable system which includes control and power panels, junction boxes, RTD and heat tracing cables in accordance with the Manufacturer's instructions and under the supervision of the Manufacturer's Representative.

7. Sump Pumps

   The Contractor shall install and connect the sump pump electrical power and control system in accordance with the Manufacturer's instructions and under the supervision of the Manufacturer's Representative.

8. Thermosyphon

   The Contractor shall make the required connections for the electrical supply of the refrigerating units of the thermosyphons.

4.0 QUALITY CONTROL

4.1 General

1. Testing and commissioning of all work on site shall be in accordance with detailed programs and procedures prepared by the Contractor and approved by the Manager's Representative.

2. The Contractor shall provide on site all personnel, equipment, instruments, wiring, etc. required to carry out the tests and record their results in a satisfactory manner. The Contractor shall calibrate all necessary test instruments and equipment, and include calibration records in the respective test reports.

3. The Manager's Representative reserves the right to witness any tests., The Contractor shall advise the Manager's Representative at least 10 working days prior to the start of such tests.

4.2 Pre-Operational Testing

1. The Contractor shall carry out pre-operational testing of all the electrical systems. Pre-operational testing shall include but not limited to inspections and tests involving continuity of wiring, meggering, tap setting, calibration, adjustment, motor rotation and operation and activation of all electrical equipment and systems.

2. The Contractor shall get the Manager's Representative approval of the pre-operational tests before proceeding at the commissioning of all electrical systems.

3. Distribution Panel Insulation

4. The Contractor shall carry out a ground insulation test for each single phase distribution panel with all circuit breakers closed and their connected cables de-energized. Measures shall be made between phases and between each phase and the ground. The Contractor shall use a 500 V Megger. The minimum acceptable insulation resistance shall be of 25 mega ohms.

5. Transformer Tap Setting

6. The Contractor shall adjust the transformer taps in order to get on secondary terminals a voltage as close as 240/120 V.

7. Cables

   The Contractor shall carry out an insulation withstand test of all power and instrumentation cables. The tests shall be as follow:

   - For 600 V power cables, one minute hold test with 1000 V megger.
   - For 240/120 V power cables and instrumentation cables, one minute hold test with 500 V megger.

8. Pump Motors

   Before starting a pump motor for the first time, the Contractor shall test the motor circuit under the supervision of a Manufacturer's Representative. He shall:

   - Check the motor rotation and correct if necessary
   - Measure the supply voltage at each phase of the motor
   - Measure the nominal current at each phase of the motor
   - Check the setting of overload elements
   - Inspect the motor for proper cable connections and frame grounding connections
   - Perform megger test of power and control wiring.

9. Pipe Heat Tracing Cable

   The Contractor shall make all the pre- operational testing of the heat tracing cable system in accordance with the Manufacturer's instructions and under the supervision of the Manufacturer's Representative.

10. Remote monitoring system

    The Contractor shall simulate all alarms and events which are programmed to be monitored and ensure that they are effectively received at the remote central monitoring station

4.3 Test Reports

1. Test reports shall indicate the tests performed, instruments used, names of test personnel and provide for witnesses signatures. They shall also be numbered and dated.

2. The Contractor shall compile records of each and every test and bind such test documents in the same manner as the Operation and Maintenance Manuals.

4.4 Operator and Maintenance Manual

1. The operator and maintenance manual shall be supplied by the Contractor. This manual shall contain all the information necessary to perform the maintenance and the operation in a safe manner and all the applicable bulletins of sub - suppliers. The manual shall be in English.

4.5 As Built Drawings

1. The contractor shall return to the Manager's Representative an as built drawing set. All changes made during the construction must have been approved by the Manager's Representative.

-END OF SPECIFICATION

AMEC EARTH & ENVIRONMENTAL	Technical Specification **15 KV OVERHEAD DISTRIBUTION LINE**	Revision	
		No.	Date
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1.0 CODES AND STANDARDS

1. Design and install the overhead line to 15 kV class for the A418 dike in accordance with CSA and Northern Canada Power Commission standards and practices, with respect to: pole setting, clearances, line stringing, sagging, tensioning, clamping, splicing, pole and line grounding, identifying and testing.

   Obtain approval of the NWT Mine and Safety Branch or local governing authority once installation is complete.

2. The equipment covered by this Specification, including all components, wiring and auxiliaries shall be designed, manufactured and tested in accordance with the latest applicable standards;

CSA:	Canadian Standards Association.
CEC-C22. 1 EEMAC/NEMA:	Canadian Electrical Code Part 1.
IEEE:	Electrical and Electronic Manufacturers Association of Canada/National Electrical Manufacturer's Association Institute of Electrical and electronics Engineers.
ANSI:	American National Standards Institute.
CAN/CSA-M421 :	Use of electricity in Mines.
CAN/CSA-C22-3 No. 1:	Overhead systems.

2.0 DESIGN CRITERIA

Assumed loading, tensioning criteria and clearances shall be submitted for approval.

3.0 OPERATING CONDITIONS AND DUTY

The overhead line shall be designed and installed for the following requirements.

1. Operating temperature to -54°C. Non operating (storage temperature) - 54°C to + 40°C. Maximum operating temperature = 30°C.

2. Duty: continuous, 24 hours per day, 365 days per year.

4.0 OVERHEAD LINE DETAILS

4.1 Equipment

Voltage	13.8 kV, 3 ph, 60 Hz
Transformers, pole mounted*	For DPS-6: 3x75 kVA, 1 ph, 13.8 kV-347 V For each thermosyphon: 3x25 kVA, 1ph, 13.8 kV-347V Delta/Star, Dyn 1
Transformer connection Transformer Neutral, grounding Number of feeders from 13.8 kV switchgear	Solid 2
Load interrupter switches	400 A, 3 pole, gang operated
Fuse cutouts, with links	100 A, 1 pole
Road crossings	Cable underground in steel culvert
Lighting fixtures	400 W, 347 V HPS, street light fixture

*** Single phase transformers are furnished with 2 HV and 2 LV bushings.**

4.2 Overhead Line Materials

Number of Circuits	**O**ne (1), 3 phase (according to drawings)
Approximate length, total Average Span	50 - 55 m
Poles	Western Red Cedar, class 2
Pole height	40 ft (12.19 m) and 45ft (13.71 m) for pole with transformers
Cross arms	Douglas Fir, 9 ft
Suspension insulators Tension insulators Conductors	Epoxy – clamp top pin type 15 kV
Messenger wire	Epoxy
Guy wire	Partridge, 266.8 MCM, ACSR
Grounding wire	7/16” steel wire 7/16” steel wire
	Copper # 2 – AWG for transformers and messenger ground every three wood poles

5.0 POLE INSTALLATION

5.1 Excavation

The pole line shall be erected along the established roads. The pole spotting shall be made such that road grading and ground clearing vehicles shall not interfere with the pole structures. The contractor shall carry out any preparation of the site necessary to perform its operations such as excavation, drilling, blasting, shoring and dewatering that may be required at each pole structure site for proper installation of wood poles and guy anchors.

Open excavations in areas where animals or the public may be endangered shall not be left unattended without first providing suitable covers, fences or barricades around the perimeter of the excavation. Any conditions resulting from the Contractor's work which, in the opinion of the Manager Representative constitutes a hazard shall be corrected to the satisfaction of the Manager Representative.

The Contractor shall ensure that the overhead line is protected from possible slides, washouts or other hazards resulting from its road construction, grading benching and other site preparation work and operations. Surface drainage shall be directed away from any pole.

Treated wood poles shall not be installed in the immediate vicinity of running or standing water. Wood poles set in winter shall not have snow or frozen soil in backfill. Contractor is responsible for 12 months warranty on pole and anchor installations and must re-backfill and compact poles not properly installed.

Contractor supplied dating nails shall be installed in each pole below the manufacturer's stamp at a distance of 3.6 meters from the butt of the pole. Butts of poles are not to be shaved or shortened in any way. Tops of poles may be removed to adjust height if properly roofed and treated.
Excavated material shall be defined as follows:

- Rock is defined as all solid or ledge rock or boulders which, in the opinion of the Manager Representative, cannot be removed until loosened by blasting;
- Earth is defined as all material other than rock as defined above, including, but not restricted to earth, sand, gravel, hardpan and soft or disintegrated rock.

The Contractor may encounter swamp settings where the butt of the pole is not resting on firm soil. In these areas, the Contractor shall install timbered and crib foundations on such poles.

5.2 Pole erection

All wood poles structures and material shall be handled and erected carefully to avoid bending and damage to components.

Handling of wood poles shall be done as per pole standard CAN/CSA-015-90.

Wood poles structures shall be assembled and erected in accordance with the approved drawings. During structure erection, particular care shall be taken to prevent possible cracking or other damage to structure.

All ground assembled sections must be supported by blocking to ensure proper alignment of all sections, cross arms and panels.

Install guying as to conform to the requirements of applicable standards.

Guying across the roads shall not be allowed.

Install anchors as to conform to the requirements of the applicable standards.

Rock anchors, if used, must be grouted. All overburdened rock anchors must have anchor extensions. Contractor shall provide warranty of all anchors for 12 months.

Waste material shall be spread or removed to the satisfaction of the Manager Representative.

Wood poles shall conform to the Wood Utility Poles and reinforcing Stubs Standard CAN/CSA-015.

Wood poles to be Penta treated as per CAN/CSA-80.

Wood cross-arms shall conform to CSA specification 0116.

5.3 Pole Mounted Equipment

Install single phase pole mounted transformers, distribution class lightning arrestors, fused disconnect switches, lighting fixtures, potheads for Teck cable connection and other associated hardware as required, on poles located as per drawings.

5.4 Conductor Installation

Each overhead pole line shall consist of three (3) conductors per circuit and one (1) underrun messenger wire.

All conductors stringing shall be carried out using equipment and sheaves of a type which will not damage the conductor or compression joints.

The conductor shall not be dragged across the ground or other abrasive surface. Particular care shall be exercised at all times to ensure that the conductor does not become kinked, twisted, abraded or damaged in any way.

Compression joints and compression dead-end assemblies shall be installed in accordance with manufacturer's specification and instructions as shown on the Contractor drawings.

All conductors to be spliced shall be cleaned and treated in accordance with the manufacturers instructions and accepted construction standards immediately prior to splicing.

The sags shall be determined from the Contractor supplied sag and tension data sheets.

The Contractor shall submit as part of design requirements sag and tension data sheets for each section of the line design between dead-ends. The sag and tension data sheets shall include the following information, the section of line identified by pole structure numbers from/to, the ruling span, initial sags and tensions, final sags and tensions. The sags and tensions data sheets shall be supplied for temperatures from -54 to +30°C. This information shall be of such a quality to be used by the Contractor's employees to sag the conductor according to the design criteria. The Manager Representative will use the same data to inspect the work.

The conductor shall be left in travelers for a minimum of twelve hours, and sag checks shall then be made at every fourth span (and corrected if necessary) before clamping. Long steeply inclined spans and extra long spans tend to accumulate conductor and produce excessive tensions in adjacent spans. Clamping in will be done immediately.

On completion of sagging any one section, the Contractor shall submit to the Manager Representative, on approved forms, the exact sag measurements of each control span.

Permanent markers in the form of single dating nails shall be installed at the point of measurement on both poles/structures in the control measurement span.

Proper tensioning of conductor is the responsibility of the Contractor. Contractor is liable for any line breakage caused by over tensioning.

Compression dead-end and connector assemblies shall be used for dead-ends and jumpers for phase conductors. The conductor shall be cleaned and treated according to the manufacturer's installation instructions and construction standards.

5.5 Grounding

All equipment, pole hardware and lightning arrestors on each pole structure are to be bonded and grounded.

The Contractor shall provide and operate instruments capable of testing selected ground rod and counterpoise installations to determine their effectiveness. The Manager Representative will determine the location for the tests.

Installation of counterpoise shall consist of all work necessary for, or incidental to, the excavation in earth and rock, installation of counterpoise and termination as required on Contractor drawings. It is the responsibility of the Contractor to measure the soil resistance and, where required, specify and install additional counterpoise.

GEM material supplied by Owner will be used to enhance grounding if required.

5.6 Road Crossing

Dead-end the line at both sides of the roads. Supply, terminate and install cables under the road in the road culverts provided by others. Leave sufficient slack at each end for cable thermal expansion.

5.7 Pole Mounted Transformers

Install single phase, oil filled transformers on the poles in accordance with the drawings. Each transformer shall be protected by a fuse and a lightning arrestor.

The transformer shall be connected to form a Delta/wye configuration (Dyn1).

Connect transformer neutrals directly to ground through a copper link to allow transformer isolation from the ground grid when required.

5.8 Lightning Arrestors

Lightning arrestors shall be located immediately adjacent to the equipment protected. The down lead from the arrestor to a ground rod shall be as short and as direct as possible and shall be free of sharp bends. The ground rod shall be bonded and interconnected to the pole grounding.

5.9 Pole Mounted Gang Operated Switches

The load interrupter switches where indicated on the drawings, shall be pole top mounted and operated by a single handle at the bottom of the pole. The switch ratings shall be as shown on the drawings.

Install gradient control mat at the base of the structure, below the handle and connect to the station ground and the switch control handle by a flexible 2/0 AWG copper conductor.

A minimum of 150 mm of crushed gravel shall be spread over the mat and the area treated to prevent growth of plants.

On the pole structure, the frame of the switch shall be grounded by 2/0 WG conductor.

5.10 Street Lighting

Install street lighting using flood lights on the poles as shown on the drawings. The power for lighting shall be taken from pole mounted transformers in accordance with the single line diagram.

Each flood light shall be protected by a 27 kV fused cutout.

5.11 Clean-up After Completion

The area for each section of the line deemed to be completed shall be thoroughly cleaned of any debris and left in pristine condition.

6.0 ECOLOGICAL AND ENVIRONMENTAL

The Contractor shall take particular care to avoid unnecessary disturbance or damage to the land, waterway, riparian areas and environment and shall correct to the satisfaction of the Manager Representative any condition which has resulted from his operations and which constitutes, or which could result in unnecessary damage or disturbance to property and the environment.

The Contractor shall repair, to the satisfaction of the Manager Representative, any damage to roads or ways, culverts or any other works or structures, which results from their operation.

Air and water pollution, erosion an aesthetics will be critically monitored by the Manager Representative.

In order to protect the soil and wildlife the Contractor shall conduct all operations in and efficient manner, using appropriate land management and conservation practices and shall:

- Minimize all forms of pollution;
- Prevent the fouling of streams, creeks and other waterways, lakes, swamps, ponds and other watercourses;
- Minimize soil erosion and preserve ground stability, including restoration to a satisfactory condition of any disturbance or damage to property.

Disturbance of soil shall be avoided wherever practicable. Grading and benching shall be kept to a minimum. All grading and benching shall be carried out to the satisfaction of the Manager Representative.

The use of vehicles and equipment in a manner which, in the opinion or the Manager Representative, would cause unnecessary damage or increase the possibility of erosion will not be permitted.

The Contractor shall take care not to unduly disturb the ground in any archaeological site areas.

7.0 SPARE PARTS AND TOOLS

All spare parts required shall be constructed with the same materials and workmanship as the originally furnished parts and shall meet the same standards.

Quote a separate price for the above mentioned spare parts. These spare parts may be purchased by the Manager Representative during the contract.

List any required special tool or equipment that may be necessary or convenient for handling, (assembling or disassembling), maintenance, and installation of the equipment and quote a separate price for them.

8.0 TYPICAL POLE STRUCTURES

The Contractor shall design the following typical structures and provide them in their required configuration:

- Tangent and light angle (up to 16°) structure (AL)
- Medium angle (16 to 50°) structure (MA)
- Large angle (50 to 90°) structure (LA)
- Dead-end structure (DE)
- Section dead-end structure (SDE)

The Contractor may choose to use typical NCPC related structures and detailed drawings listed below provided that they do satisfy all design requirements.

1.	Tangent/Light angle	NCPC	DS-U-30 1
2.	Dead end	NCPC	DS-U-306
3.	90 degree angle, heavy angle	NCPC	DS-U-308
4.	Crossing, overhead	NCPC	DS-U-3 14
5.	Section dead end	NCPC	DS-U-313
6.	Section, tap	NCPC	DS-U-318
7.	Section switching	NCPC	DS-U-323
8.	Transformer switch, tangent	NCPC	DS-T- 1
9.	Transformer, 3 x 1 ph connection	NCPC	DS-T- 8
10.	Transformer pole mounted, 3 x 1 ph	NCPC	DS-T-11
11.	Pole setting, swamp	NCPC	DS-I-33
12.	Pole setting, soft ground	NCPC	DS-I-34
13.	Pole setting, soil and rock	NCPC	DS-I-35
14.	Pole clearances	NCPC	DS-C-8
15.	Clearances to connection, circuits	NCPC	DS-C-10
16.	Clearances to connection detail	NCPC	DS-G-3
17.	Fence Enclosure	NCPC	DS-G-2
18.	Gang Switch, grounding	NCPC	DS-G-4
19.	Interconnection of Grounds	NCPC	DS-G-5
20.	Danger signs	NCPC	DS-I-24
21.	Pole marking signs	NCPC	DS-I-3 1
22.	Spacing for joint pole use	NCPC	DS-I-32
23.	Wood stub	NCPC	DS-I-36
24.	Dating Nail locations	NCPC	DS-I-38

-END OF SPECIFICATION

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1.0 GENERAL

1.1 Reference Standards

1. American Society for Testing and Materials.
    a) ASTM A53B - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

1.2 Environmental Protection

1. Comply with the requirements of Specification VM00467-14300-41ES-0002 (Environmental Protection) and of the Water License.

1.3 Submittals

1. Submit piezometer installation plan. Include:
    a) material lists,
    b) equipment lists,
    c) manufacturer's installation procedures,
    d) installation sequence,
    e) spares list,
    f) installation details and drilling method,
    g) quality control procedures.

1.4 Sequencing

1. Coordinate work so that instruments will not be damaged by construction equipment or personnel.
2. Install all piezometers, other than installations at the dike toe, prior to commencing dewatering.

2.0 PRODUCTS

2.1 Materials for Casagrande Piezometers

1. Piezometer minimum 19 mm (inside diameter) PVC schedule 80 pipe with watertight flush threaded joints and end caps.

2. Polyethylene piezometer tip about 300 mm long, 60 micron pore size, 37 mm outside diameter.

3. Coated bentonite pellets, high density, in watertight containers.

4. Concrete sand conforming to standard CAN/CSA 3-A23.1.

5. Two water level indicators: about 10 mm dia. probe; 50 m long, epoxy coated steel tape covered with polyethylene jacket, 1 mm graduations; light and buzzer signals and battery test button.

6. All accessories and installation materials as recommended by manufacturer.

7. Schedule 40 steel pipe ASTM A53B with lockable cap as shown on the drawings.

8. Non shrink low strength cement grout consisting of 100 liters of water, 25 kg of type 10 Portland cement and 5 kg of bentonite to be hydrated for 6 hours prior to preparing grout.

9. Vermiculite used as insulation material.

2.2 Materials for Vibrating Wire Piezometers

1. Piezometer Unit

Stainless steel 19 mm diameter housing with low air entry filter and integrated thermistor, range from 0 to 350 kPa and 0 to 170 kPa with maximum overload of twice the measuring range, built in surge/lightning protection, resolution of 0.025% of full scale, accuracy of ±0.1% of full scale, serial number and range to be etched on housing, complete with calibration chart.

Integrated thermistor to have a range of -30° to +60 °C with an accuracy of 0.5 °C.

2. Cables

Shielded cables with 2 pairs of 22 AWG conductors with ground wire and polyethylene jacket. Cables for individual piezometers to be supplied without joints to lengths required for connection to junction boxes to be located near the upper extremity of each drill hole.

Individual cable lengths shall correspond to the distance between the piezometer tip and the fill surface, increased by an extra 4 m length to allow for the availability of a lead above fill surface and for variations in the elevation of the anticipated stratigraphic contacts.

3. Bentonite pellets, high density, in watertight containers

4. Concrete sand conforming to standard CAN/CSA 3-A23.1.

5. One portable readout unit compatible with vibrating wire piezometers and thermistors, with data logging capacity (min. 2000 data sets), transfer capability to PC, -20°C to 50°C minimum operating temperature limits, complete with rechargeable battery, battery charger (120 V, 60 Hz), backup battery, interface cable and adapter to connect to PC, jumper cable and computer software.

6. Junction Boxes

   Weatherproof stainless steel boxes, type NEMA 4X, to house surge arrestor protection boxes permitting connections between piezometer cables and multiconductor cables as indicated on drawings.

7. All installation and readout accessories as recommended by the manufacturer.

8. Schedule 40 steel pipe ASTM A53B with cap, as shown on drawings.

9. Non shrink cement grout as for Casagrande piezometers.

2.3 Storage

1. Store all materials and equipment in heated, weatherproof storage area, away from direct sunlight.

2. Store PVC pipes as recommended by manufacturer in factory shipping crates stored flat to keep straight.

3.0 EXECUTION

3.1 Drilling

1. As specified in VM00467-14300--0003, drill holes for piezometers into dike fill and foundation, with minimum diameters as shown on the drawings and as approved by Manager's Representative.

2. Case the holes with drill casing as required. Casing to be withdrawn as the piezometers are installed and grouted.

3.2 Installation

1. Install piezometers in accordance with manufacturer's recommendations.

2. Install piezometers as indicated on drawings or as otherwise directed by Manager's Representative.

3. Non-shrink grout or bentonite pellets to be used to fill the hole between two successive piezometers. If used, non-shrink grout shall have set before the installation of the upper piezometer is commenced.

4. Piezometer cables to be extended and/or grouped in junction boxes for connection to multiconductor cables that are routed to data acquisition system as per the requirements of Specification 015803-31 60-4GEF-0007.

5. Cables to be buried as shown on drawings and as per the requirements of Specification 015803-3 120-4GEF -0009.

6. Hand over equipment, readout unit and spares in full working order to Manager's Representative at completion of installation.

4.0 QUALITY CONTROL

1. Testing for Vibrating Wire Piezometers

- Upon receiving on site, verify that instruments are in good operating condition and all parts and related materials are available.
- Prior to installing, test for functional status and record initial (zero) readings (frequency and temperature).
- After installing the piezometer to the specified depth and prior to grouting/backfilling, test for functional status and compare the calculated pressure with the height of the water column measured above the piezometer.
- After completing instrument installation, take readings and record.
- Prior to, during and after cable burial, check functional status.

4.1 Report

- Submit calibration chart of vibrating wire piezometers.
- Submit a detailed installation report and corresponding sketches, including elevation of platform level, bedrock, till, Zone 1A/1C blanket, piezometer tips, bentonite seals, initial (zero) readings (frequency and temperature) and subsequent readings taken during various installation phases of vibrating wire piezometers.

-END OF SPECIFICATION

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1.0 GENERAL

1.1 Environmental Protection

1. Comply with the requirements of Specification VM00467-14300-41ES-0002 (Environmental Protection) and of the Water License.

1.2 Submittals

1. Submit an inclinometer installation plan. Include:

    a) material lists,

    b) equipment lists,

    c) manufacturer's installation procedure,

    d) installation sequence,

    e) spares list,

    f) installation details and drilling method,

    g) non- shrink cement grout mix.

    h) quality control procedures.

1.3 Sequencing

1. Install all inclinometers prior to commencing dewatering.

2.0 PRODUCTS

2.1 Materials for Inclinometers

1. Mobile Inclinometer Probe

One stainless steel inclinometer probe with two force balanced servo-accelerometers, 0.5 m long wheel base, resolution of 0.02 mm per 500 mm, -20° to +50°C minimum operating temperature limits, complete with 50 m long neoprene covered control cable with steel core and vulcanized depth marks on 0.5 m intervals, one slip-ring reel and one pulley assembly with cable clamp.

2. Readout Unit for Mobile Inclinometer Probe

One portable inclinometer readout unit, capable of storing and validating data in the field and downloading to a PC. Complete with rechargeable and backup batteries. Minimum operating temperature limits: -20°C to 50°C.

3. Software

Most recent Windows compatible version of all software required to transfer, process and graph inclinometer data.

4. Inclinometer Casing

Standard ABS plastic or fiberglass self-aligning casing, 85 mm OD in 3m sections complete with standard couplings in bedrock and telescopic couplings in cutoff wall capable of accommodating 75 mm in compression or extension.

5. Accessories

All accessories including inclinometer probe calibration chart, as provided by manufacturer.

6. Non-shrink cement grout.

7. Concrete head box and steel casing as shown on drawings.

2.2 Storage

1. Store all materials and equipment, in heated, weatherproof storage area.

2. Store inclinometer casing as recommended by manufacturer in factory shipping crates, stored flat and evenly supported to keep casing straight and to prevent spiraling. Store away from direct sunlight.

3.0 EXECUTION

3.1 Drilling

1. Drill inclinometer hole into cutoff or in Zone 1B fill after completion of jet grouting and pressure grouting, after approval by Manager's Representative and in accordance with specification 015803-3150-4JEF-0003. Minimum hole diameter as shown on drawings.

2. Allow minimum 24 hr from completion of pressure grouting and 7 days from completion of diaphragm wall and jet grouting before commencing drilling for inclinometer in cutoff.

3.2 Installation

1. Install inclinometer casing and couplings at locations and depths indicated on the drawings and in accordance with manufacturer's recommended procedure.

2. Attach a grout pipe to exterior of inclinometer casing extending to bottom of borehole. Grout the annulus around the inclinometer casing with non-shrink cement grout, through the grout pipe and inject grout until the annular space around the inclinometer casing is completely filled with grout. Fill inclinometer with water prior to grouting to counter buoyancy and to prevent the ingress of grout or deleterious materials into the casing.

3. Orient casing in borehole with one pair of grooves in a plane perpendicular to the dike axis. Do not disturb the inclinometer casing until grout has set.

4. Install concrete head box and steel casing as shown on drawings.

5. Circulate clean water to flush out any grout or debris from the casing.

6. Verify proper operation with mobile inclinometer probe.

7. Hand over inclinometer probe, readout unit and spares in full working order to Manager's Representative at completion of installation.

4.0 QUALITY CONTROL

4.1 Report

1. Submit a detailed installation report for each inclinometer including respective elevations of inclinometer bottom, bedrock, till and dike fill materials.

2. Submit inclinometer probe/readout unit calibration charts.

-END OF SPECIFCATION

AMEC EARTH & ENVIRONMENTAL	Technical Specification **SURVEY MARKERS / PINS** **SURVEY CONTROL MONUMENTS**	Revision	
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1.0 GENERAL

1.1 Reference Standards

1. American Society for Testing and Materials.

    a) ASTM A53B - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

2. Canadian Standard Association.

    a) CAN/CSA-G30.18, Billet-Steel Bars for Concrete Reinforcement.

1.2 Environmental Protection

1. Comply with the requirements of Specification VM00467-14300-41ES-0002 (Environmental Protection) and of the Water License.

1.3 Submittals

1. Submit an installation plan for survey markers/pins and survey control monuments. Include:

    - material lists
    - installation procedures
    - installation sequence
    - installation details and drilling method quality control procedures.

2.0 PRODUCTS

2.1 Materials

1. Reinforcing steel 25 mm diameter CAN/CSA-G30.18.
2. Brass survey cap.
3. Concrete in accordance with specification 015803-3 120-41EF-001 1.
4. Schedule 40 steel pipe ASTM A53B with cap.
5. Non-shrink cement grout.
6. Concrete sand.
7. Bentonite pellets, high density, in watertight containers.

3.0 EXECUTION

3.1 Drilling

1. As specified in 015803-3150-4JEF-0003, drill hole in dike fill, diaphragm wall, overburden and rock at locations indicated on drawings.

3.2 Installation

1. Install survey pins into upper surface of diaphragm wall or concrete guide walls if left in place, and locate by survey (horizontal precision 10 mm, vertical 5 mm) prior to burial by dike fill.

2. Install survey markers at locations determined by Manager's Representative.

3. Install survey control monuments as shown on the drawings.

4.0 QUALITY CONTROL

4.1 Report

Submit detailed reports indicating installation details, location (x, y and z coordinates and station/offset) and reference numbers of markers, pins and monuments.

-END OF SPECIFICATION

AMEC EARTH & ENVIRONMENTAL	Technical Specification **THERMISTOR CABLES**	Revision	
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1.0 GENERAL

1.1 Reference Standards

1. American Society for Testing and Materials.

    a) ASTM A53B - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

    b) ASTM D1784 - Specification for Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated Poly Vinyl Chloride (CPVC) Compounds.

    c) ASTM D2466 - Specification for Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 40.

1.2 Environmental Protection

1. Comply with the requirements of Specification VM00467-14300-41ES-0002 (Environmental Protection) and of the Water License.

1.3 Submittals

1. Submit thermistor installation plan. Include

    a) material lists,

    b) equipment lists,

    c) manufacturer's installation procedures,

    d) installation sequence,

    e) spares list,

2. non-shrink grout mix suitable for permafrost conditions,

    g) installation details and drilling method,

    h) verification of proper operation,

    i) quality control procedures.

1.4 Delivery, Storage and Handling

1. Carefully store materials to protect against deterioration and physical damage.

1.5 Sequencing

1. Coordinate work so that ground temperature cable will not be damaged by construction equipment or personnel. Install all cables prior to dewatering.

2.0 PRODUCTS

2.1 Materials

1. Thermistor Beads

YSI Model 44033 or an approved alternate bead with a 0.1°C accuracy and a nominal resistance of 2.252 ohms at 25°C.

2. Cable

Cable of stranded copper conductors, water block, 11 pairs of insulated conductors, 24 gauge with a kevlar jacket.

3. Connectors

Supply cable with an Amphenol connector comprising the following components; a shell end (97-3057-1012- 1), male insert (9720-29P), male shell (97-3106A-20), and screw cap (9760-20P) with chain attachment to shell end.

4. Thermistor Molding

Heat injection polyurethane molding, or an approved alternate, to seal the thermistor beads. The outside diameter of the molding should be compatible with installation in a 25 m m I.D. PVC pipe. The cable shall remain watertight under a water head of 100 m.

5. Identification Tag

An identification tag, permanently installed, with the project name and ground temperature cable serial number.

6. Ground Temperature Cable Casing

Schedule 80, 25 m m I.D. PVC pipe, conforming to ASTM D1784 and ASTM D2466.

7. Containment Piping

25 m m I.D. schedule 80 PVC pipe with watertight flush threaded joints and end caps.

8. Steel Casing and Head Box

Schedule 40, ASTM A53B steel pipe with head box, as shown on drawings.

9. Terminal Boxes

Weatherproof type NEMA 4X boxes to house 17 pin Amphenol female connectors mounted on a panel.

10. Multimeter

A digital multimeter with two decimal place display at 30 kilo ohms, and with an accuracy of ±0.5% and resolution of .01 kilo ohms, such as FLUKE model 87E-III.

2.2 Cable Fabrication

1. Provide cables with a total of 16 beads except where indicated otherwise on drawings. Cable fabrication details are as follows:

   a) Beads are to be spaced within 10 m m of the required location on the cable.

   b) Bead are to be installed at depths and intervals as indicated on drawings.

   c) Provide sufficient lead cable above the first bead to extend the cables to the head boxes, terminal boxes or data loggers as applicable.

   d) Wire cables preferably using the wiring code as shown on Table 1 to enable compatibility with cables currently existing on site.

Table 1 - Thermistor Cable Wiring Details

THERMISTOR BEAD NUMBER	WIRE COLOUR (Note 1)	TERMINAL LETTER ON CONNECTOR
1	RED	A
2	BROWN	B
COMMON	GREY	M
3	BLACK	C
4	WHITE	D
5	BLUE	E
6	PURPLE	F
COMMON	BROWN	M
7	ORANGE	G
8	GREEN	H
9	YELLOW	J
10	BLUE	K
COMMON	GREY	M
11	RED	L
12	BLACK	N
13	WHITE	P
14	PURPLE	R
COMMON	GREY	M
15	GREEN	S
16	BLUE	T
COMMON	ORANGE	M
COMMON	YELLOW	M

Note 1: Wire color not mandatory, but preferable

e) Mark the identification and serial number of each cable permanently onto the body of the connector.

f) Prepare the cable harness by removing 25 to 35 m m length of cable jacket (jacket cutouts) at each bead location and extract the appropriate wire for the bead location and the common wire for the cable.

g) Solder beads to both wires with some slack incorporated into the wiring and placed on the outside of the cable bundle. During soldering, protect the beads to keep their temperature below manufacturer's recommended limit.

h) Cover the beads with a layer of heat reflectant tape with the adhesive side not in contact with the bead. Place a second layer of heat reflectant tape with the adhesive side down to 15 m m on either side of the jacket cutout.

i) Cover each bead with injection molding extending a minimum of 40 m m above and below the bead location.

2.3 Thermistor Calibration

2. Verify that each ground temperature cable is functioning properly and calibrate the thermistor beads. Use the following calibration procedure:

a) Prepare bath of ice and water cooled to at least 0.03°C and monitor the temperature with a thermometer accurate to 0.01°C.

Immerse each section of the cable with a thermistor bead into the ice bath and after it reaches thermal equilibrium, record the resistance reading using a digital multimeter as specified above. Repeat the process a minimum of three times and determine average 0°C correction for each bead.

3.0 EXECUTION

3.1 Installation of New Cables

1. Install cables after obtaining approval by Manager's Representative.

2. As specified in Specification 015803-3150-4JEF-0003, drill hole for cables into dike fill and foundation with minimum diameters as shown on drawings.

3. Case the holes with drill casing as required.

4. Install the containment PVC pipe to the bottom of the hole. Verify that the pipe is clean and dry.

5. Casing to be withdrawn as the annulus between the casing and the containment PVC pipe is being filled with dry sand.

6. Install cable in PVC pipe and locate first bead as indicated on drawings.

7. On dike crest, cables are to be buried in fine grained protective fill in trenches excavated in the dike fill, as shown on drawings and as per the requirements of Specification 015803-3120-4GEFG-0009. Thermistor cables installed adjacent to thermosyphons are to be grouped and extended to individual terminal boxes as indicated on drawings.

8. Cables in trenches are to be laid with a minimum slack of 1 m per 10 m length and a minimum spacing of 50 m m between cables.

9. Hand over equipment, readout unit, spares in full working order to Manager's Representative at completion of installation.

3.2 Extension of Existing Cables

1. Remove existing cable connector and attach suitable length of extension lead of same type cable. Connect extension wire by soldering. Protect soldered connection on individual wires with heat shrink tubing and further protect entire wire bundle with a single piece of heat shrink tubing of a diameter equivalent to the cable insulation.

2. Drawings.

3. Protect existing thermistor cable installations during dike construction as noted in Specification 015803-3120-4GEF-0008.

4.0 QUALITY CONTROL

4.1 Testing

Check that each thermistor operates properly prior to installation and cable burial.

4.2 Report

4. Submit a detailed installation report foreach thermistor cable including respective elevations of working platform, bedrock, till, dike fill and bottom and top and bottom thermistors.

5. Submit resistance and temperature relationships and procedure for application of calibration corrections.

-END OF SPECIFICATION

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1.0 GENERAL

1.1 Reference Standards

ASTM A53B	Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A312	Specification for Seamless and Welded Austenitic Stainless Steel Pipe

1.2 Environmental Protection

1. Comply with the requirements of Specification 015803-31 20-4EEF -0002 (current no.?) «Environmental Protection» and of the Water License.

1.3 Submittals

1. Submit a relief well installation plan. Include:

    a) material lists,

    b) installation procedure,

    c) installation sequence,

    d) installation details and drilling method,

    e) well development method,

    f) pump specifications,

    g) quality control procedures.

1.4 Sequencing

1. Install all relief wells prior to commencing dewatering.

1.5 Delivery, Storage and Handling

1. Carefully handle and store materials to protect against deterioration and physical damage.

2.0 MATERIALS

2.1 Materials for Relief Wells

1. Riser
2. Grade B, schedule 30, 6 inch nominal diameter steel pipe.
3. Screen
4. Wire-wound continuous V-slot fabricated of cold drawn triangular wire wound around an internal array of longitudinal support bars, AISI (ANSI?) type 304 stainless steel; 6 inch nominal diameter with wall thickness capable of supporting the overlying riser pipe without deformation.
5. Joints and Caps
6. Bottom cap to consist of welded stainless steel plate. Top cap to consist of standard well cap. Joints to consist of stainless steel welding rings.
7. Filter Material
8. Filter material to consist of Zone 1 material scalped on a 20 mm sieve.
9. Centering Guides
10. Centering guides to consist of four 12 gauge steel blades and clamps as shown on drawings.
11. Protective Casing
12. 200 mm nominal diameter steel tubing, as shown on drawings.
13. Pumps
14. Submersible pumps with a capacity of 25 l/min under a dynamic head of 30 m.

3.0 EXECUTION

3.1 Location

1. The actual location of each relief well will be selected by Manager's Representative based on the subsurface conditions established during the various phases of dike construction.

3.2 Drilling

1. Drill holes 5 m into bedrock at locations approved by Manager's Representative after the dike has been built to its final elevation.
2. Drill using a temporary casing of minimum 300 mm diameter to support the hole walls and prevent the formation of cavities around the casing.
3. Use of bentonitic drilling fluid is forbidden. Biodegradable drilling fluid may be employed provided environmental requirements are met.

3.3 Installation

1. Assemble sections of riser and screen as shown on drawings taking into account the stratigraphic conditions established during the cutoff wall construction, jet grouting and pressure grouting phases.
2. Install centering guides on minimum 6 m centers on the riser only, ensuring that the blades are adequately aligned and that the annulus around the riser and screen is uniform.
3. During installation in the hole, ensure the assembled sections of screens and risers are lowered with great care to prevent damage to the screens. Wells in which a submersible pump cannot be lowered to the base of the lower screen due to buckling or tearing of the screen sections shall be replaced at cost to the Contractor.
4. After approval by Manager's Representative, place filter material at the bottom of the hole, as shown on drawings.
5. Lower the assembled riser/screen/centering guides into the hole and start placing the filter material using a tremie to avoid material segregation.
6. Initially, the tremie pipe shall be lowered to the bottom of the hole, filled with filter material and gradually lifted.
7. Gradually lift the temporary casing while ensuring that its lower end is always buried at least 1 m into the filter material.
8. Around the lower part of the riser, place concrete sand material up to about 0.3 m above the overburden - Zone 1A interface as indicated on drawings.
9. Develop the well using the surging method or any other approved method to remove fine particles present in the screen or in the surrounding filter material. Add filter material in the well annulus if required to maintain its upper level at the specified level.
10. Development is considered complete when water is clear and free of visible suspended sediments.

11. Install the protective casing as shown on drawings.
12. Install a submersible pump and associated discharge pipe in wells selected by Manager's Representative.

4.0 QUALITY CONTROL

1. Prior to assembling the riser and screen sections, submit for approval by Manager's Representative a cross-section for each well indicating: the respective elevation of bedrock, till and zone 1A/1C blanket, and proposed elevation of upper and lower ends of each riser.
2. .Submit a detailed construction report at completion of each relief well.

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1.0 GENERAL

1.1 Submittals

1. Submit a plan for the data acquisition system. Include:

    a) material lists,

    b) equipment lists,

    c) installation procedure,

    d) installation sequence,

    e) cable layouts;

    f) wiring diagrams;

    g) spares list;

    h) data processing software and user's manual,

    i) quality control procedures.

2.0 PRODUCTS

2.1 Materials for Data Acquisition System

1. Data Loggers

   Data logger model 2380 by Geomation Inc. complete with all ancillary equipment to ensure compatibility with existing system at A154 dike. System to include weather proof boxes, switch boxes, measurement and control units, adaptors, multiplexers, multistage transient arrestors, interface modules as necessary and accessories, rechargeable batteries with self sufficiency of 24 hours during power outage, battery charger, backup batteries to support loggers until AC mains power becomes available, fixed frequency licensed microwave type radio modems model MDS 4710A by Microwave Data Systems, antennas, coaxial cable and connectors and all devices to acquire and transmit data from instruments identified on drawings to the gateway data logger to be located as directed by Manager's Representative. AC mains power provided by others. Data loggers to allow measurements in switch boxes using portable readouts.

2. Software and Programming

   Most recent Windows compatible version of all necessary software and programming to acquire, transmit and retrieve data, to perform real-time graphic display and alarm management as well as to produce and access graphs.

3. Multiconductor Cables

   All shielded heavy duty multiconductor cables and related accessories required to group and connect instruments to individual data loggers as indicated on drawings.

4. All accessories and materials required to ground data loggers and instruments.

5. Corrugated Polyethylene Pipe

   100 m m diameter.

6. Data Logger Shelters

   Approximately 1.5 m x 1.5 m x 2.4 m high shelters made of gauge 14 steel, with 2 lifting hooks on roof, one anchor plate at each corner, a neoprene gasket and silicone seal on the perimeter of the bottom frame, R-20 insulated walls and roof, approximately 81 cm x 203 cm insulated steel door and internal/external epoxydic paint protection.

7. PVC Pipe

   150 m m diameter PVC pipe.

2.2 Storage

1. Store all equipment in heated, weather proof storage area.

3.0 EXECUTION

3.1 Installation

2. Cables

   Cables to be buried within fine grained protective fill in trenches excavated in the A418 dike crest and downstream toe berm as shown on drawings and as per the requirements of Specification 015803-3120-4GEF-0009. Cables to be installed with a minimum uniform slack of 1 m per 10 m length and with a minimum spacing of 50 m m between each cable. Actual trench locations and alignments shall be approved by Manager's Representative prior to execution. Cables installed on the downstream slope of the dike shall be contained in a corrugated polyethylene pipe protected by backfill as indicated on drawings.

3. Data loggers

   Data loggers to be installed in shelters on the dike crest as indicated on drawings. Actual locations of data loggers may be adjusted, with Representative's approval, to optimize the number of loggers and the lengths of cables and trenching required.

4. Software and Programming

   Software to be installed at central workstation and programming performed to enable the instrumentation system to be operated as per the Owner's requirements regarding reading frequencies, data display and alarm management. Owner's requirements to be specified on site.

5. Hand over spares in full working order to Manager's Representative at completion of installation.

4.0 QUALITY CONTROL

4.1 Testing

1. Instrumentation and software to be tested for proper operation.

4.2 Report

1. Submit a detailed installation report complete with wiring diagrams and cable layouts.
2. Submit an operation manual for the automated instrumentation system.

-END OF SPECIFICATION

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1.0 GENERAL

1.1 Environmental Protection

1. Comply with the requirements of Specification 015803-31 20-4EEF -0002 (Current No?) «Environmental Protection» and of the Water License.

1.2 Climatic Conditions

1. See the «Site Conditions» specification no. 015803-3120-41EF-0001 (Current No.?) for information.

1.3 Design Criteria

1. The thermosyphons shall have sufficient heat transfer capacity and be adequately spaced to maintain the abutment/island interface frozen at all times based on the following design criteria:

    a) Climatic information as published by the Atmospheric Environmental Service of Environment Canada.

    b) Granular material thermal properties to be based on a density of 2000 kg per cubic meter at 7% moisture content.

    c) Use of safety factor of 2.0.

1.4 Reference Standards

1. American Society for Testing and Materials.

    a) ASTM A53 Grade B - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

    b) ASTM B88M and B280 - Copper Tubing for Refrigeration Services

2. Steel Structures Painting Council.

    a) SSPC-SP10 - Near-White Blast Cleaning.

3. American Society of Mechanical Engineers

    a) Boiler and Pressure Vessel Codes.

4. Northwest Territories Codes and Regulations.

1.5 Submittals

1. Submit shop drawings of thermosyphons and condensing units, piping and connection details, including supports, insulation and accessories.

2. Submit manufacturer's recommended installation and operation procedures, including procedures for cleaning pipes, welding, on site painting, vacuuming, charging, pressure testing and leak detection.

3. Submit design analysis and calculations to demonstrate adequacy of the system and compliance with the required design criteria.

2.0 PRODUCTS

2.1 Materials

1. Thermosyphons

a) Two phase liquid-vapor type thermosyphons charged with carbon dioxide as manufactured by Arctic Foundations of Canada Inc., Winnipeg, Manitoba or equivalent.

b) Construct the evaporator section of the thermosyphons from black steel pipe (not galvanized) in accordance with ASTM A53, 2 inch NPS, Sch. 40 Grade B.

c) All welds to meet ASME boiler and pressure vessel code requirements.

d) Sandblast the thermosyphon radiator, the above ground pipe and the upper 2.2 m of the evaporator below ground to near white condition in accordance with SSPC-SP10, aluminize and paint with white epoxy paint.

e) Construct radiators from ASTM A53, 3 inch NPS, Sch. 40 Grade B black steel pipe with segmented carbon steel fins, 1.2 m m thick, 13 rows of fins per 100 m m of pipe and a total radiator area 19.5 m_2.

f) Typical dimensions of the evaporator and radiator are as shown on drawings.

g) Each thermosyphon shall have a minimum thermal conductance value of 178 W/°C for a wind velocity of 8 km/hr.

h) Include a heat exchanger encased in an insulated ASTM A53, 6 inch NPS, Sch. 40 Grade B black steel pipe. The active heat exchanger shall comprise a 9.5 m m seamless Sch. 80 steel cooling coil through which a refrigerant (R404A) can be circulated from a condensing unit.

i) Include the insulated part of ASTM A53, 2 inch NPS, Sch. 40 Grade B black steel pipe, and 6 inch, Sch. 40 Grade B black steel pipe as shown on drawings

2. Condensing Unit

a) 30 hp, 600 volt, 3-phase, 60 Hz, air cooled condensing unit, rated at a capacity of 65 kW (225,600 BTU/hr), at an operating temperature of –18oC for each group of 16 thermosyphons. Apart from

standard equipment (semi hermetic compressors, aluminum condenser fans/guards, discharge and suction line vibration isolators, condensing coils, flooding head pressure control valve, fan cycling, etc.), each condensing unit shall include a suction accumulator with replaceable filter, heated and insulated liquid receiver, head cooling fans, CO2 thermostat/thermowell, replaceable liquid line kit with solenoid valve and fused disconnect switch.

b) Refrigerant R404A or approved alternate.

c) Refrigerant shall be circulated through a type «L» ACR copper tubing header with connections to each individual thermosyphon. The refrigerant piping shall be sized by the Contractor/Manufacturer but in no case shall be less than 25 mm for the supply liquid line and 50 mm for the suction vapor return. If the characteristics of the condensing unit change, the piping network shall be modified accordingly. All brazed joints to be done with Stay-Brite Tin-antimony (96-4) alloy.

3.0 EXECUTION

3.1 General

1. Carry out piping (also implies thermosyphons) installation in a neat permanent workmanlike manner, workmanship being equal, in every respect to the best practice known to the trade.

2. Piping dimensions, fabrication, assembly, welding and installation shall conform to all applicable sections of the ASME/ANSI B31.1 code, chapters I V and V .

3. Piping and fittings shall be clear and free from cutting or threading burrs, scales and defects. Ream the ends of all piping.

4. Arrange and install piping as indicated, straight, plumb, as direct as possible. On parallel piping runs, leave a minimum free space of 1 5 0 m m to allow for expansion.

5. Install the electrical equipment from a 600 V , 5 phase, 60 Hz source provided by others.

3.2 Location

1. The final layout of each thermosyphon group will be selected by Manager's Representative after determination of the location of the permafrost boundary during the construction of the dike.

2. Excavation and backfill shall be done according to the specification No. 015803-3 120-4GEF-0009 (current no.?).

3.3 Thermosyphon Installation

1. Supply a skilled crew specialized in fabrication, assembly, charging and testing the thermosyphon system.

2. Install thermosyphon evaporators in cased drill holes with a minimum 4 inch inner diameter.

3. The radiators shall be erected plumb and shall be braced to each other in a manner that will allow them to be free standing. Install the thermosyphons within the following tolerances:

   a) Horizontal location at dike surface: 100 m m

   b) Inclination: 2°

   c) Elevation: 100 m m

4. Place the evaporator in the drill hole in sections. Welding to be carried out by thermosyphon manufacturer. Provide a crane to lift and install the evaporator sections in the drill hole.

5. Remove the casing following installation of the evaporator. Alternatively, with the Manager's Representative approval, the casing may be left in the drill hole. If the casing is left in the drill hole, the annulus between the casing and the evaporator must be filled with sand slurry or an

equivalent approved by Manager's Representative. Record accurate measurements of the volume of sand slurry used in the annulus to verify that the annulus is completely filled.

6. Welding of the radiator, the heat exchanger and the insulated part to the evaporator to be carried out by the thermosyphon supplier. Provide a crane to lift and support the radiator section during welding.

7. Charging of the thermosyphons with CO_2 to be done by the thermosyphon supplier.

3.4 Welding

1. All pipe welding shall be done by competent welders.

2. Fabricate piping according to the Pipe Fabrication Institute Standard ES-3 «Fabricating Tolerances».

3. Welding procedures and welders shall conform to the ASME code «Boiler and Pressure Vessel», section XI, «Welding and Brazing Qualifications».

4. Submit welding procedures and welders qualification certificates to the Manager's Representative. No welding to commence without his approval. Include the procedure(s) for storing, handling, control and distribution of electrodes and wires. Wet electrodes shall be discarded. Each procedure shall be certified and registered by the Boiler and Pressure Vessel Branch of the Local Jurisdiction. The procedures shall be qualified on the same grades of pipe materials as those to be welded during fabrication.

5. Ends and adjacent surfaces shall be free of all traces of paint, oils, lubricants and rust, prior to commencement of welding.

6. All butt welding shall be full thickness penetration. The bottom of a "stub-in" shall be flush with the pipe. Care shall be taken to ensure a minimum of weld metal deposit on inside of piping.

7. Pipe welding shall conform with the following codes:

CSA-W47.1	Certification of companies for fusion welding of structural steel.
CSA-W48.1	Mild steel covered arc-welding electrodes.
CSA-W48.3	Low-Alloy steel arc-welding electrodes.
CSA-W1 17	Code for safety in welding and cutting.
CSA-W178	Qualification code for welding inspection organisation.

3.5 Flange Assembly

1. Flange facings shall be true, parallel and perpendicular to the axis of pipeline. Bolt connections properly. Pull bolts evenly tight to ensure leak proof and stress-free connections. Bolt holes shall straddle centrelines. Steel flanges are normally raised face, but flanges that are to be bolted to cast iron, bronze or plastic full face flanges shall be furnished with a flat face and fitted with full face gaskets.

3.6 Threaded Joints

1. Make piping threaded joints tight with an approved pipe joint compound or tape.

3.7 Dielectric Joints

1. Install dielectric unions or insulated couplings between copper or brass piping material and steel material. Use approved union or insulated couplings for pipe sizes 2" and smaller, and approved dielectrically gasketed flanges for pipes 2½" and larger.

3.8 Branch Connections

1. For welded pipes, use straight tees or reducing tees if commercially available. Otherwise, use «Weldolets» or «Sockolets». Cut-in welding connections shall not be used.

2. Outlets for small valves, air vents, drains, etc. not exceeding ¾" size may be made by extra strong half-couplings welded to the main.

3.9 Connections to Equipment

1. Make connections to equipment so that lines do not impart any stress on equipment due to misalignment, deflection and expansion. The mating flange of the pipeline shall be the same type as on equipment.

3.10 Valves

1. Install all the necessary valves required to adequately control piping services and equipment and as shown on drawings. Install a valve at each pipe connection to equipment and one at each branch connection to a main.

3.11 Reducers

1. Where pipeline is graded to a low point, avoid the formation of pockets that will trap the liquid in the pipe. Unless otherwise specified, use eccentric reducers. In general, avoid large reduction in one single fitting. Use two or more eccentric reducers in series. Fabricated reducers are not acceptable.

3.12 Fittings

1. Unless otherwise indicated, elbows shall be of the long radius type.

2. Simplify layout so as to keep fittings to a minimum.

3.13 Slopes

1. Refrigerant piping shall be pitched with a slope of not less than 1:240, unless otherwise indicated on drawings.

3.14 Supports, Anchors and Guides

3.14.1 General

1. Support piping by hangers or other supports as shown on drawings or as required at maximum spacing specified below.

2. Install necessary anchors and guides in proper relation to expansion swings or bends to control, limit and direct the thrust of expansion in piping. Locate them where shown on drawings and elsewhere as required.

3. Support independently every pipe that is connected to a fixture or a piece of equipment.

4. Copper piping shall not be in contact with steel, iron or ferrous materials.

3.14.2 Spacing

1. The maximum horizontal spacing of the copper piping supports shall be as follows:

(Formatting required)Piping Size	Maximum Spacing, meters inch
½	1.5
¾	1.5
1	1.8
1¼	1.8
1½	2.4
2	2.4
2½	2.4
3	2.4
4	2.4
6	2.4

3.15 Additional Requirements for the Mechanical Refrigeration

1. Refrigeration work to be done according to CSA B52-M, ASME/ANSI B31.5 code and to ARI and ASHRAE standards using certified frigorists.

2. Welding test in accordance with ASME B31.1.

3. Use only ACR seamless copper tubing that has been cleaned and sealed at the factory, meeting ASTM B88M and B280 standards. Piping shall remain sealed until it is assembled and connected to the equipment.

4. Fittings to be forged copper or forged brass, conforming to ASTM B 16.26 and B 16.29 standards. For connections that need to be dismantled, use flare joints.

5. Circulate dry nitrogen when welding capillary effect. Use an Alloy with a maximum melting point of 600°C. Weld pipes and fittings using a Tin/Antimony 96-4 Alloy, such as «Harris» «Stay-Brite». Prepare joints using a «Stay-Clean» flux.

6. Supply and install service connections compatible with the use of «Glo- Stick» leak detection capsules.

7. Install piping for proper oil return to compressors.

8. Suction side branch connections to be done from the main suction pipe crown (top).

3.16 Cleaning

1. Before connecting to equipment, or closing of pipeline, flush out or otherwise clean piping thoroughly of any foreign matter.

2. Clean refrigerant piping with refrigerant R-11 or R- 113. Do not purge refrigerant to atmosphere. Recover the whole refrigerant content using approved refrigerant recovery equipment.

4.0 QUALITY CONTROL

4.1 Testing

1. Prior to commissioning, pressure test piping network for leak detection including refrigeration, piping and thermosyphons. There shall be no allowable leakage.

2. Use helium leak detection mass spectrometers for the thermosyphons.

4.2 General

1. Provide the required labor, equipment and instrumentation for the complete testing of the piping systems as described below.

4.3 Refrigerant Piping Systems

4.3.1 Leak testing

1. Refrigeration leak testing to be done according to CSA B52-M. However, maintain a minimum of 2000 kPa on the high pressure side and 1000 kPa on the low pressure side.

2. Test refrigerant piping with refrigerant R-22 used as fluid leak indicator. Add the «Glo-Stick» capsules from «Spectroline» designed for R22. Localize leaks with a Halogen detector and the «Spectroline» fluorescent detection system («Glo-Stick» and U V lamp).

3. Set initial pressure at 35 kPa and add dry nitrogen to raise pressure to the required test pressures. Isolate equipment from piping during the test.

4. Repair the leaks and repeat the test.

4.3.2 Dehydration

1. Use a 2 stage vacuum pump equipped with a gas injection device on the second stage enabling the creation of an absolute vacuum of 0.05 m m . For the purpose, the vacuum pump shall be dehydrated and filled with new oil.

2. It is forbidden to use the refrigeration compressor for the dehydration operation.

3. Install a thermocouple type vacuum-meter graduated in «mm». Install a manual shut-off valve between the vacuum pump and the vacuum-meter and take readings only when the piping network is isolated from the vacuum pump.

4.3.3 Running test and adjustment

1. Supply all instruments, measuring equipment and tooling required for the tests. Adjust controls according the manufacturer's calculations and recommendations.

2. Complete the piping insulation work and the accessories installation prior to this test.

3. Check ambient temperature (dry and wet bulb) and operating refrigerant pressures for comparison with the recommended manufacturer's data.

4. Check the running tension (volt) and current (amp) and compare them with those of the motor nameplate. Check the motor protections at the starter for correct selection. The power of each phase shall be similar to each other with a precision of 100 V A .

4.4 Report

1. Submit test reports for approval.

2. Submit as-built plan, section and detail drawings of thermosyphons and condensing units and piping network.

3. Submit monthly progress report, including location, installation details, etc. Moreover, for each thermosyphon group, submit installation report, including a profile along each thermosyphon alignment, and show respective elevations of working platform, dike fill, till and bedrock, bottom elevation of thermosyphon evaporators and insulation pipes.

-END OF SPECIFICATION